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Ground-water Resources of the Loysville and Mifflintown Quadrangles in South-Central Pennsylvania

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Ground-water Resources of the Loysville and Mifflintown Quadrangles in South-Central Pennsylvania

by Herbert E. Johnston
U.S. Geological Survey

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GROUND-WATER RESOURCES OF THE MIFFLINTOWN AND LOYSVILLE QUADRANGLES IN SOUTH-CENTRAL PENNSYLVANIA

by

Herbert E. Johnston

ABSTRACT

The Loysville and Mifflintown quadrangles include an area of about 460 square miles of valley and ridge terrain in south-central Pennsylvania. This area is underlain by strongly folded sedimentary rocks that consist chiefly of sandstone, siltstone, shale, and limestone of Ordovician, Silurian, and Devonian age*

The rocks are deeply weathered and in most places are covered by a mantle of unconsolidated to semiconsolidated rock residue (saprolite) that ranges from less than 1 foot to about 50 feet in thickness. The permeability of this material is low, but its high storage is an important aspect in the hydrology of the area. Water-bearing openings in the consolidated bedrock, which are chiefly fractures, decrease in size and number as depth increases. Most drilled wells in the study area tap no more than two or three significant water-bearing openings in the upper 100 feet of bedrock.

Two test wells were drilled on fracture traces, one in the calcareous shale of the Wills Creek Formation and one in the Tonoloway Formation. Neither well penetrated deeply weathered or extensively fractured rock, as have wells drilled on these features in carbonate rocks in a nearby area. The test well in limestone did penetrate a solution opening, however, and the 1-hour specific capacity of 62 gpm per foot (gallons per minute per foot of drawdown) was the highest measured during this study. The specific capacity of the other test well was about the same as the average for wells in the Wills Creek Formation.

Yields reported for more than 500 wells range from less than 1 gpm (gallons per minute) to 275 gpm; the median yield is 12 gpm. Fewer than 5 percent of the wells were reported to yield more than 50 gpm, and fewer than 3 percent were reported to yield less than 1 gpm. The median well yields for individual formations and members do not differ greatly; they range from 6 to 20 gpm. Most of the

*The geologic nomenclature in this report is that of the Pennsylvania Topographic and Geologic Survey and does not necessarily coincide with that of the U.S. Geological Survey.

yield data were obtained from domestic wells that were drilled no deeper than was necessary to obtain a yield of 5 to 10 gpm. Most of these wells are between 50 and 170 feet deep; their median depth is 88 feet.

Short-term (mostly 1-hour) specific capacities determined at low pumping rates (generally less than 25 gpm) for 79 wells, are relatively low—indicating that the average permeability of the bedrock is low. The specific capacities ranged from less than 0.1 gpm per foot to 62 gpm per foot, but the median value was only 0.55 gpm per foot.

Analysis of specific-capacity data by frequency distributions indicates that wells in calcareous shale and limestone of Late Silurian and Early Devonian age generally exhibit higher specific capacities than do wells in the dominantly noncalcareous shales and sandstones of other geologic periods. Analysis of these data with regard to the topographic position of the wells indicates that, for a given rock type, the higher specific capacities are generally exhibited by the wells in valleys. The specific capacities of wells in valleys, for any given frequency of occurrence, are about double those on hillsides and hilltops. This indicates that the permeability of various rock types tends to be somewhat higher in valleys than on hillsides and hilltops.

Evaluation of reported-yield data, specific-capacity data, and borehole-flow data from the deepest wells inventoried indicate that the principal yielding zones generally occur above a depth of about 200 feet.

Mapped rock units were assigned to one of three general categories—good, fair, or poor—according to their estimated potential for yielding water to wells. Assignments were made in part on the basis of specific-capacity data and in part on topographic and lithologic considerations. Units of good yielding potential include the interval of calcareous shale and limestone between the Wills Creek and the Onondaga Formations. Units of fair yielding potential include the noncalcareous shales, sandstones, and interbedded sandstones and shales that overlie and underlie the calcareous units, exclusive of the units that underlie the crests and steep slopes of the principal ridges and mountains. The latter are considered to have poor yielding potential. Rock units having the greatest potential are the Wills Creek and Tonoloway Formations. These units underlie considerably more valley area than other calcareous rock units.

Water from calcareous shales and limestones generally has a dissolved-solids content of 200 to 300 mg/l (milligrams per liter) and the water is generally hard to very hard. Water from the non-

calcareous shales, siltstone, and sandstones generally has a total dissolved-solids content of 100 to 200 mg/l. and is generally soft to moderately hard.

Locally, the Wills Creek and Tonoloway Formations yield water containing excessive concentrations of sulfate hardness, rendering the water unfit for many uses. Iron is present in bothersome or noticeable amounts in water from several wells that tap noncalcareous shales and sandstones. Units in which reports of iron were common include the Martinsburg, Reedsville, Marcellus, and Mahantango Formations. Concentrations of iron in all units ranges from 0.1 to 2.6 mg/l. Several wells in the black shales of the Martinsburg, Reedsville, and Marcellus Formations, and a few wells in dark shales of other dominantly nonclacareous formations, yield water containing bothersome or noticeable amounts of hydrogen sulfide gas.

Hydrologic conditions exist in many areas that may result in the downward movement of shallow ground water into wells containing too little casing or casing around which the annular space is inadequately sealed. Such movement may result in bacterial contamination of wells in areas of closely spaced homes that are served by on-lot sewage-disposal systems. It is recommended that wells be cased and grouted to a depth of 50 feet. However, even this precaution may not prevent pollution of a well if polluted water is allowed access to deep zones in the bedrock through faultily constructed wells nearby.

Use of ground water in the study area is negligible in comparison to the available supply. The average use of ground water and surface water in five communites served by public distribution systems was only 0.19 million gallons per day in 1964. About 27 percent of this amount was obtained from wells.

INTRODUCTION

PURPOSE OF THIS INVESTIGATION

Little information is available concerning the ability of the folded sedimentary rocks of the mountainous region of central and south-central Pennsylvania to yield water to wells. This study was undertaken to determine the water-yielding potential of more than 20 formations in the Loysville and Mifflintown quadrangles (Fig. 1) and to evaluate the relationships of factors such as topographic position, rock type and structure, and depth of aquifer penetration on the yield of wells. From these relationships it was expected that criteria could be established for drilling wells to optimum depths in areas where the chances of obtaining above-average yields are most favorable.

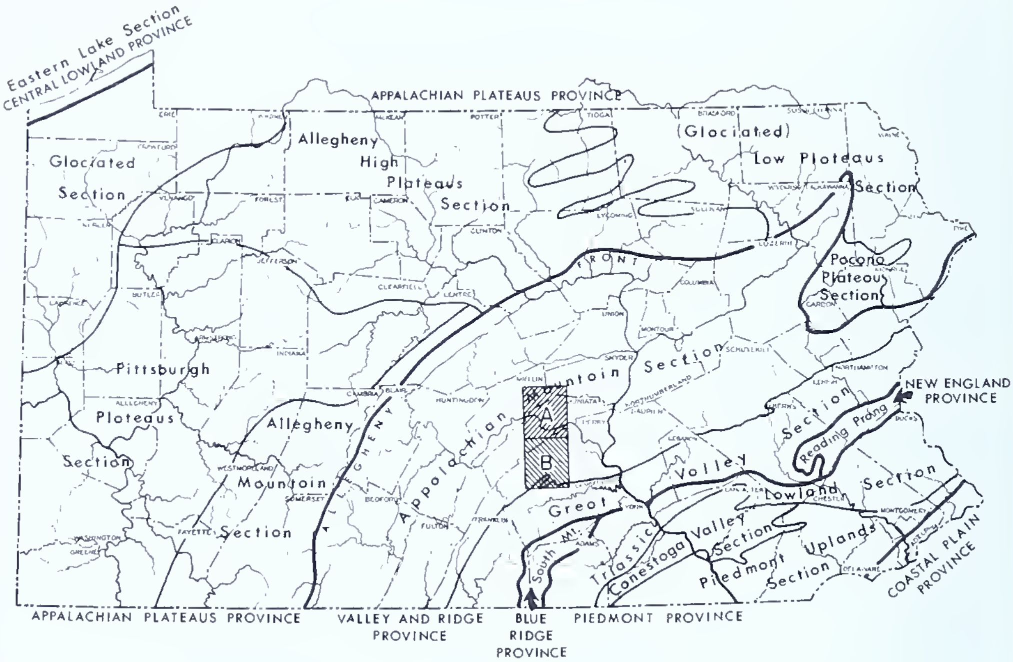


Figure 1. Map of Pennsylvania showing the location and the physiographic divisions in the area of the Mifflintown (A) and Loysville (B) quadrangles.

The study area was selected because most of the formations that underlie the study area are present throughout much of the mountainous section of central and south-central Pennsylvania, so that the results obtained will be applicable over a much larger area, and because recent detailed geologic mapping was available.

The investigation was done as part of the continuing study of ground-water resources in Pennsylvania that is being made by the U.S. Geological Survey in cooperation with the Pennsylvania Topographic and Geologic Survey.

METHODS OF INVESTIGATION

Information for more than 600 wells, most of which were drilled for domestic purposes, was obtained chiefly from drillers' records. These data were supplemented by 71 short-term (generally 1-hour) pumping tests, which were used to determine the specific capacities of the wells. Pumping rates for these tests ranged from 3 to 25 gpm.

Two test wells were drilled on fracture traces—linear land-surface features visible, primarily, on areal photographs—to evaluate the potential of such features as a prospecting tool for ground water. Also fracture-trace orientations were compared with joint orientations in the Loysville quad-

rangle to determine if these features were related to the joint systems visible in outcrops of the bedrock.

Brine-tracing methods were used to determine the rate and direction of borehole flow under both pumping and nonpumping conditions in selected wells, in an attempt to determine the depth and contribution of yielding zones. Brine slugs were introduced into the wells at known depths with a small-diameter plastic tube, and their direction and rate of movement were determined by means of a depth-calibrated fluid-resistivity sonde, suspended on a cable, and a stop watch.

Water-level measurements were made in several wells with automatic water-level recorders, to determine the magnitude of water-level fluctuations that occur in response to climatic conditions.

Samples were collected from 21 wells for complete chemical analysis, and from 22 additional wells for determination of nitrate and chloride. Field determinations of hardness and specific conductance were made at more than 300 wells, and field determinations of iron were made at 41 wells.

Water samples from 22 wells were analyzed by the membrane filter technique for coliform bacteria.

PREVIOUS INVESTIGATIONS

The geologic base maps for this study were prepared by the Pennsylvania Topographic and Geologic Survey. The Loysville quadrangle was mapped by Miller (1961), and the Mifflintown quadrangle was mapped by Conlin and Hoskins (1962).

The hydrology of the study area was covered as part of a reconnaissance study of ground-water resources in south-central Pennsylvania by Lohman (1938), and as part of a reconnaissance study of the ground-water resources of the Susquehanna River basin by Seaber and Hollyday (1965, 1966).

Streamflow, precipitation, and water quality data have been collected in the Bixler Run basin, in the west-central part of the Loysville quadrangle since 1954. The data are being collected by the U.S. Geological Survey as part of a study to evaluate the sediment-yielding characteristics of a stream draining an intensely farmed area undergoing little cultural change.

WELL-NUMBERING SYSTEMS

Two well-numbering systems are used in this report. They consist of a county system and a latitude and longitude location system.

Under the county system the wells are numbered consecutively in each county. Under the latitude and longitude system a well is assigned a number that locates it within a 1-minute grid on the hydrologic maps (Plates 1 and 2). The location number consists of two three-digit segments separated

by a hyphen: the first segment is composed of the last digit of the degree and the two digits of the minutes that define the latitude on the *south* side of a 1-minute quadrangle; the second segment is composed of the last digit of the degree and two digits of the minutes that define the longitude on the *east* side of the same 1-minute quadrangle. Both numbering systems are illustrated in Figure 2.

The first segment of the location number may be used to identify the 15-minute quadrangle in which the well is located. Location numbers beginning with 015 to 029 (40°15′ to 40°29′) identify wells in the Loysville quadrangle. Location numbers beginning with 030 to 044 (40°30′ to 40°44′) identify wells in the Mifflintown quadrangle.

TOPOGRAPHY AND DRAINAGE

The study area lies mainly in the Appalachian Mountain Section of the Valley and Ridge Physiographic Province. A small part of the Loysville quadrangle, south of Blue Mountain, is in the Great Valley Section of the province (Fig. 1). The topography is characterized by a prominent northeast-southwest alignment of a succession of narrow, steep-sided ridges and valleys.

Bottoms of the principal valleys are generally between the altitudes of 400 and 700 feet, and the crests of the highest ridges are generally between 1,500 and 2,000 feet. Relief between ridge crests and adjacent valley bottoms is greater than 1,500 feet in several areas and is commonly greater than 300 feet. The highest point in the area, at an altitude of about 2,255 feet, is on Thick Mountain, in the northwest corner of the Mifflintown quadrangle. The lowest point, at just under 420 feet, is where the Juniata River leaves the Mifflintown quadrangle.

About half of the study area is mountainous or hilly woodland, forested chiefly with deciduous trees. The area is well drained by an extensive network of streams that comprise part of the Susquehanna River drainage system. There are few marshy areas and no natural lakes or ponds. Several farm ponds and a few small stream impoundments have been constructed within the study area but their collective affect on the drainage is negligible.

Most of the southern half of the Loysville quadrangle is drained by Sherman Creek, which empties into the Susquehanna River. Most of the remainder of the quadrangle, and nearly all of the area included in the Mifflintown quadrangle, is drained by the Juniata River, a major tributary of the Susquehanna River.

Many small headwater streams flow northwestward and southeastward off the mountains and ridges, emptying into larger streams that flow in the major valleys. Gradients of streams flowing off the principal ridges are commonly 200 feet per mile, or greater. These streams generally cease flowing, or flow only a small amount, during the middle or latter part of the growing

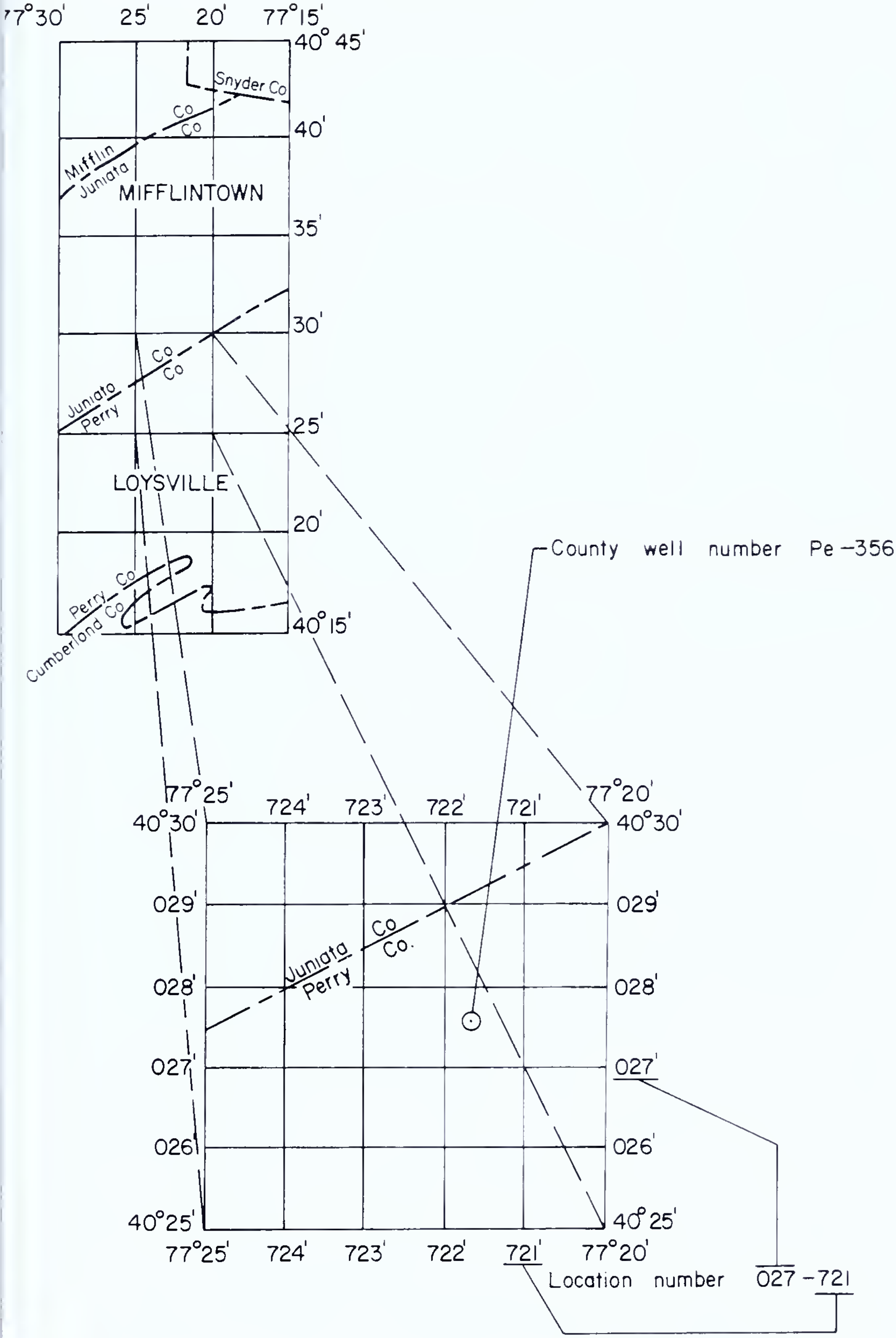


Figure 2. Sketch showing well-numbering systems.

season. Streams flowing in the major valleys have gradients of 50 feet per mile, or more, throughout much of their extent. The lowest gradients are those of Sherman Creek and the Juniata River. Sherman Creek has a gradient of about 8 feet per mile, and the Juniata River has a gradient of about 2 feet per mile.

CLIMATE

The climate of the Loysville and Mifflintown quadrangles is humid and is characterized by warm summers and cool winters. Precipitation records given in Table 1, for stations near the northern, southern, eastern, and western boundaries of the study area, indicate that the average annual precipitation on this area is about 41 inches.

Precipitation at these stations has ranged from 26 to 62 inches per year; however, distribution of precipitation is commonly fairly even throughout most of the year. During the months of December, January, and February, when much of the precipitation is in the form of snow, precipitation averages less than 3 inches per month, as compared to averages of 3 to 4 inches for all other months.

During the winter months, storm systems are generally widespread and result in a rather uniform distribution of precipitation over the area. During the summer months, most of the precipitation occurs as rainfall that, because of topographic effects, is often unequally distributed on the area.

ACKNOWLEDGMENTS

The author is indebted to borough and water-authority officials, industrial firms, and individual well owners who supplied information or permitted the use of their wells for making hydrologic measurements. Particular thanks are due Mrs. Mildred A. Smith of Loysville, Pa., and Mrs. Maude E. McClure of Thompsontown, Pa., for permitting test wells to be drilled on their properties. The author wishes also to express his thanks to the well drillers who made available well data from their files. The work of Mr. Stephen F. Talian, who assisted the author in the early phase of the investigation, is also greatly appreciated.

GEOLOGY

The geology of the Loysville and Mifflintown quadrangles has been described in detail in reports by Miller (1961) and by Conlin and Hoskins (1962), respectively. The geologic maps accompanying their reports were used as the geologic base maps for this investigation. Descriptions of individual formations and members are given in Table 2 and in the map explanations on Plates 1 and 2.

Table 1.—Average monthly and annual precipitation at stations near the Loysville and Mifflintown quadrangles
(Data from U.S. Weather Bureau records)

Station* and period of record	Average annual precipitation (inches)												
	January	February	March	April	May	June	July	August	September	October	November	December	Annual
Beavertown 1951–1960	2.72	2.96	3.61	4.06	3.88	3.39	3.53	3.95	3.38	3.01	3.68	3.03	41.20
Bloserville 1913–1960	2.87	2.26	3.68	3.87	4.48	4.08	4.27	4.85	3.46	3.52	3.52	2.98	43.84
Lewistown 1938–1960	2.41	2.04	3.35	3.31	4.34	4.04	4.01	3.63	2.83	3.23	3.22	2.57	38.98
Newport 1931–1960	2.90	2.37	3.55	3.56	4.07	3.71	4.19	4.11	3.03	3.44	3.37	3.05	41.35

*See Figure 7 for location.

Table 2.—Generalized geologic section of the Loysville and Mifflintown quadrangles

System	Series	Formation and member: Loysville quadrangle	Formation and member: Mifflintown quadrangle	Map symbol: Loysville quadrangle	Map symbol: Mifflintown quadrangle	Thickness (feet): Loysville quadrangle	Thickness (feet): Mifflintown quadrangle	Description
Devonian	Upper Devonian	Catskill		Dck		±3,500		Siltstone, shale, and sandstone.
		Catskill—Fort Littleton Transition beds		Dfc		±1,400		Interbedded siltstone, sandstone, and shale.
		Fort Littleton	Fort Littleton	Df		2,550		Sandstone, siltstone, and shalc. Shale and siltstone dominant in lower part. Sandstone dominant in upper part.
	Middle Devonian	Rush	Rush	Dr		100–200		Mostly black, thin-bedded to fissile shale; in places carbonaceous. A zone of limestone nodules and calcareous shale is common at top, at base is one or two feet of argillaceous limestone.
		Sherman Ridge		Ds		600		Mahantango Formation consists of interbedded shale, siltstone and sandstone. Upper part is dominantly shale and siltstone; lower part is dominantly sandstone. Sherman Ridge Formation is equivalent to the upper part of the Mahantango. It consists of interbedded sandstone and shale.

			Mahantango		Dmh	±1,100	Sandstone is dominant at base; shale is dominant at top. Montebello Formation is equivalent to the lower, sandy part of the Mahantango. It consists of sandstone with interbedded units of siltstone and very fine-grained sandstone. Gradational with Mahanoy and Turkey Ridge members of the Marcellus Formation south and east of Limestone Ridge.
		Montebello		Dmo Dmom Dmot		±1,000	
		Marcellus Mahanoy Member	Marcellus Mahanoy Member	Dm Dmm		75–120	Thin-bedded, laminated, silty shale, siltstone, and sandy siltstone.
		Turkey Ridge Member	Turkey Ridge Member	Dmt		100–150	Fine- to medium-grained sandstone.
		Shamokin Member	Shamokin Member	Dms		75	Carbonaceous, fissile shale. Silty near top. Calcareous in places. Contains bedded siliceous and pyrite-marcasite, nodules.
	Lower or Middle Devonian	Onondaga	Onondaga	Don		65–175	Argillaceous limestone in upper part. Grades down to calcareous shale. In Loysville quadrangle, shale at base contains phosphatic nodules. Thickens to northwest.

Table 2.—Generalized geologic section of the Loysville and Mifflintown quadrangles—Continued

System	Series	Formation and member: Loysville quadrangle	Formation and member: Mifflintown quadrangle	Map symbol: Loysville quadrangle	Map symbol: Mifflintown quadrangle	Thickness (feet): Loysville quadrangle	Thickness (feet): Mifflintown quadrangle	Description
Devonian—continued	Lower Devonian	Oriskany and Helderberg undivided	Old Port	Dho	Do		150–190	Quartz, sandstone at top (Ridgeley member) fine-grained to conglomeratic in Loysville quadrangle thins and becomes fine- to medium-grained in Mifflintown quadrangle. Underlain by chert, cherty limestone, and shale.
		Ridgeley Member of Oriskany Formation		Dor		5–35		
		Helderberg Formation and Schriver Member of Oriskany Formation		Dhs		100–150		
		Keyser	Keyser	Sk	Sky	165–180		Nodular, fossiliferous limestone.
	Upper Silurian	Tonoloway	Tonoloway	Sto		550–650		Laminated limestone and argillaceous limestone.
		Wills Creek	Wills Creek	Sw				Calcareous shale, argillaceous limestone, and siltstone; some sand-
		Upper	Upper	Swu		170–200		

Silurian		Member	Member			stone at top. Shale, siltstone, and claystone; some argillaceous limestone; some sandy limestone.
		Lower Member	Lower Member	Swl	450	
		Bloomsburg	Bloomsburg	Sb	350–500	Shale, claystone, siltstone, and sandstone. Local lentils of sandstone and conglomerate near middle in Loysville quadrangle (Bridgeport Member). In Mifflintown quadrangle contains some sandstone near middle and top, and some thin zones of calcareous shale in upper half.
		Bridgeport Member		Sbb		
	Middle Silurian	Mifflintown	Mifflintown	Sm		Limestone and interbedded shale.
		McKenzie and Rochester Members undivided	McKenzie and Rochester Members undivided	Smm	150–265	Siltstone, shale, argillaceous to silty limestone near top; intraformational breccia near base. (McKenzie Member). Underlain by shale containing interbeds of crystalline limestone (Rochester Member).
	Lower Silurian	Keefer Member	Keefer Member	Smk	30	Quartzitic sandstone containing lenticular interbeds of shale.
		Rose Hill	Rose Hill	Sr	850–900	Shale and siltstone with interbeds of shale.
		Tuscarora	Tuscarora	St	350–700	Quartzitic sandstone.

Table 2.—Generalized geologic section of the Loysville and Mifflintown quadrangles—Continued

System	Series	Formation and member		Map symbol		Thickness (feet)		Description
		Loysville quadrangle	Mifflintown quadrangle	Loysville quadrangle	Mifflintown quadrangle	Loysville quadrangle	Mifflintown quadrangle	
Ordovician	Upper Ordovician	Juniata	Juniata	Oj		1,000–2,000		Sandstone, siltstone, and shale. Quartzitic in upper part; conglomerate beds at base in Loysville quadrangle.
			Bald Eagle	Ob		±750		Medium-grained sandstone; thick section of conglomerate in middle.
		Martinsburg	Reedsville	Om	Or	1,500–2,000		Shale, siltstone, fine-grained sandstone. Siltstone and sandstone are sandstone are dominant near top.
	Middle Ordovician		Salona		Os			Interbedded calcareous shale and limestone.
			Nealmont		On			Limestone with some chert.

The rocks at or near the surface in the Loysville and Mifflintown quadrangles are part of a thick sequence of layered sedimentary rocks consisting chiefly of sandstone, siltstone, shale, and limestone. They consist essentially of two thick sequences of predominantly noncalcareous rock units separated by a thick sequence of calcareous rock units. These rocks were deposited more or less continuously during the Ordovician, Silurian, and Devonian Periods of the Paleozoic Era. The Ordovician, Silurian, and Devonian Periods cover an interval of 175 million years that began about 430 millions years ago and ended about 255 millions years ago.

The oldest rocks in the study area are the limestones of the Nealmont and Salona Formations, which are of Middle Ordovician age. These rocks underlie only a very small area in the northwest corner of the Mifflintown quadrangle, and, therefore, were not studied as part of this investigation.

Stratigraphically overlying these units is a sequence of dominantly noncalcareous, clastic rocks deposited during the Late Ordovician and Early and Middle Silurian Epochs. The rock units of Ordovician age include the Martinsburg and Reedsville Formations, which are composed chiefly of shale and siltstone, and the Bald Eagle and Juniata Formations, which are composed chiefly of sandstone, siltstone, shale, and a small amount of conglomerate. Rock units of Early and Middle Silurian age inelude the Tuscarora Formation, a relatively clean quartzitic sandstone; the Rose Hill Formation, which consists chiefly of siltstone and shale with a few interbeds of sandstone; the Mifflintown Formation, which consists of quartzitic sandstone and interbedded limestone and shale; and the Bloomsburg Formation, which consists chiefly of shale and siltstone with some interbeded fine-grained sandstone.

This dominantly noncalcareous sequence was followed in the Late Silurian and Early Devonian Epochs by the deposition of rocks having a moderately to strongly calcareous composition. The rock units in this stratigraphic interval include the largely calcareous shale and siltstone of the Wills Creek Formation; limestone of the Tonoloway and Keyser Formations; limestone, shale, chert, and sandstone of the Helderberg, Oriskany, and Old Port Formations (units mapped in the Loysville quadrangle as the Helderberg and Oriskany Formations were mapped in the Mifflintown quadrangle as the Old Port Formation); and limestone and calcareous shale of the Onondaga Formation.

These calcareous rocks were buried during Middle and Late Devonian time by a thick sequence of essentially noncalcareous rock units composed dominantly of interbedded sandstone, shale, and siltstone. However, the Marcellus and Rush Formations contain thick units composed chiefly of shale and siltstone, and the Montebello Formation consists chiefly of sandstone.

Near the end of the Paleozoic Era, the long period of subsidence and concomitant sedimentation ended in the area and the sedimentary layers

were then uplifted and subjected to forces (the Appalachian Revolution or Uplift) that produced large folds and some rupturing (faulting). Subsequent erosion sculptured a series of northeast-southwest trending ridges and valleys that are closely accordant with the capability of the rocks to resist weathering. The mountain crests are underlain chiefly by resistant sandstone; the valleys are underlain by less resistant limestone and soft shales. Units of intermediate resistance underlie minor ridges.

Deep burial and folding of the rock units has produced rocks that are nearly everywhere tightly cemented and compacted. The rocks have little primary porosity or permeability. Their capacity to store and transmit water is related to the degree of fracturing and the degree to which fractures have been enlarged by the processes of weathering.

Exposures of bedrock are sparse, owing to the deeply weathered zone that persists throughout much of the area. In many areas the geologic contacts were determined largely on the basis of float and on topographic and tonal features that are visible on aerial photographs. Although the contacts are reasonably accurate, considerable caution must be exercised when attempting to drill from one unit into another in the vicinity of a contact. Because of the steep dip of the bedding in many places, relatively small differences in well placement at the surface may result in substantial differences in the depth to which a well must be drilled in order to penetrate a given unit.

STRUCTURE

Major structural features of the Loysville and Mifflintown quadrangles parallel the general northeast-southwest topographic grain of the folded Appalachian region of Central Pennsylvania. Axes of the major folds and faults trend N 55°-65° E.

Thick competent units, such as the sandstones and shales of the Bald Eagle, Juniata, and Tuscarora Formations, have been folded into broad, slightly asymmetrical folds and in places exhibit small-scale faulting. Units such as the Wills Creek and Tonoloway Formations, which are composed of many thin beds of shale, siltstone, and limestone of varying competency, tend to be very incompetent as a whole. These units have responded to tectonic stresses by complex small-scale folding and faulting, especially along the crests and troughs of major folds. Similar complex folding has developed in the incompetent shales of the Martinsburg, Reedsville, Marcellus, and Rush Formations. Units of intermediate competency include the Rose Hill, Bloomsburg, Keyser, and Monetbello Formations. These units are relatively thick and homogeneous and contain few crenulations and complex folds.

Axial planes of most folds dip steeply, usually to the northwest. None of the folds are overturned. The majority of the folds plunge northeastward in the Loysville quadrangle, but doubly plunging folds are common in the

Mifflintown quadrangle. The plunge of the folds ranges from 5° to 22° but is generally on the order of 5° to 10°.

There are few large-scale faults in the study area, but there are many small-scale faults in the incompetent shales and limestones. Most of the mappable faults are of the high-angle (45°–90°) type. Small-scale normal faults occur locally in tightly folded units sueh as the Wills Creek and Tonoloway Formations.

Bedding dips steeply throughout most of the area. Dips of less than 20° occur near the axes of folds, but generally the dip exceeds 20°. In some areas the bedding is vertical, and in many areas dips of more than 50° are common.

The geologic reports of the Loysville and Mifflintown quadrangles do not contain descriptions of the joints in the bedrock. However, joint data from the field notes of the authors of these reports were made available by the Pennsylvania Geological Survey. These data are summarized in the following paragraphs, so that the general trends of these structures may be compared with those of fracture traces as discissed in the following section. The data include 181 joint measurements for the Loysville quadrangle and 152 joint measurements for the Mifflintown quadrangle.

The data indicate that the rocks are systematically jointed and that the joints have two markedly preferred orientations. One prominent joint set trends N 50°–60° E, parallel to the general strike of the bedding and parallel to the trend of the major structural features of the bedrock. The other prominent set trends N 20°–40° W, or at nearly right angles to the general strike of bedding. Trends of joint data for the Loysville quadrangle are shown in Figure 3. Trends of joint data for the Mifflintown quadrangle are nearly identical.

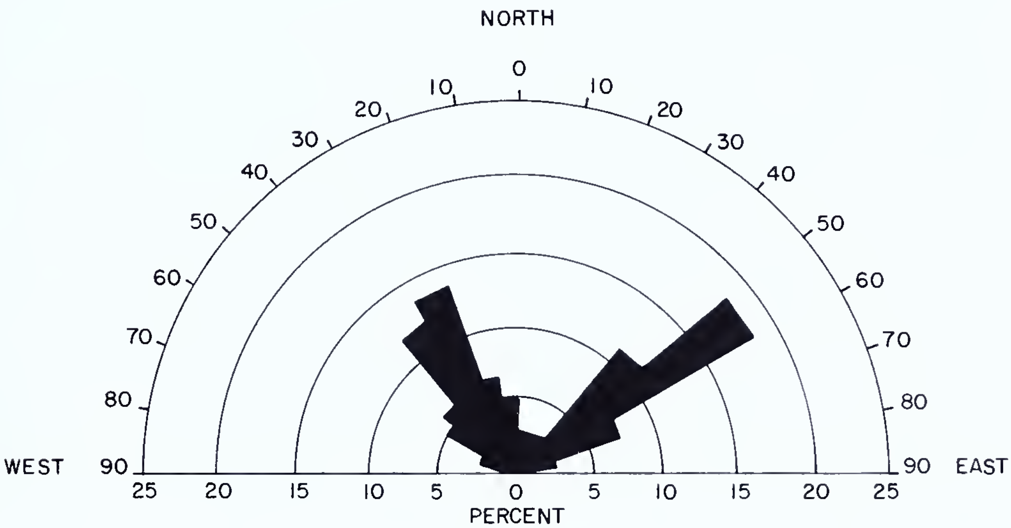


Figure 3. Semi-circular histogram showing orientation of 181 joints in the Loysville quadrangle.

Joints that strike normal to the strike of the bedding generally dip more steeply than those that strike parallel to the strike of the bedding. More than 60 percent of the northwesterly striking joints have a dip of 80° or more, and more than 80 percent have a dip of 70° or more. By comparison, only 24 percent of the northeasterly striking joints have a dip of 80° or more, and only 42 percent have a dip of 70° or more.

Joints are commonly well developed in competent sandstone or limestone beds that are interbedded with less competent beds of shale and siltstone. Generally, only one or two joint sets are well developed, but three well-developed sets occur in some outcrops; and four sets are present in a few outcrops.

The majority of the joints that are visible in outcrops are spaced less than 1-foot apart and commonly are no more than a fraction of an inch wide. Joints usually are more widely spaced in sandstones and limestones than in shales and siltstones. The majority of individual joints do not cross bedding planes.

Fracture Traces

Fracture traces are natural linear features that are visible on aerial photographs, and are believed to be surface expressions of fractures in the underlying bedrock. These features were examined in the study area primarily to determine their potential as a means of locating zones of above-average permeability in the bedrock.

Lattman (1958, p. 569) has defined fracture traces as natural linear features consisting of topographic (including straight stream segments), vegetational, or soil-tonal alignments, which are visible primarily on aerial photographs, and are expressed continuously for less than 1 mile. Similar features that are expressed continuously for at least 1 mile, and continuously or discontinuously for several miles, are defined as lineaments.

Fracture traces do not include linear features that are obviously related to bedding, striation, foliation, and stratigraphic contacts. They are believed to be related to individual joints, zones of closely spaced joints, or small-scale faults. Lineaments, some of which are 50 miles long, are thought to be surface expressions of vertical planes deep in the earth's crust. Inasmuch as these features remain straight over irregular topographic surfaces, they are believed to be steeply inclined. Traces of slightly to moderately inclined fractures would be sinuous in areas of substantial relief and probably would not be recognized as fracture traces on aerial photographs.

The visibility of fracture traces and lineaments on aerial photographs is commonly attributed to differences in moisture content or in the degree of development of soils along linear zones; the settling of soil into underlying fractures; and the preferential development of sinkholes, gullies, or streams along fractures or fracture systems.

It is generally difficult or impossible to see the majority of these linear features on the ground, although parts of some traces may be identified as aligned topographic depressions.

Fracture traces were identified and plotted on photographs of the entire Loysville quadrangle and parts of the Mifflintown quadrangle. Plotting was done on photographs at a scale of approximately 1:20,000, first with the unaided eye, then with a stereoscopic lens. Using a photographic enlarger, projections of photographs were reduced to a scale of 1:24,000 so that the fracture traces could be transferred to topographic maps of the same scale. Few fractures were plotted in forested sections—which include more than 50 percent of the Loysville quadrangle—because of the difficulty in distinguishing the numerous wood-lot lines of past timbering operations from natural linear features. Also, few traces were plotted parallel to the general northeast-southwest strike of beding because of the possibility of mistaking bedding traces for fracture traces. Only the most conspicuous linear features were plotted. Most of the plotted features were identified in the field as soil-tonal alignments, small-scale linear topographic depressions, or a combination of the two. A few, however, were drainage tiles, old trails, or traces of former fence rows. When using photographic linear features to select well sites, care should be taken to determine that they are not man-made features.

Azimuths of the 448 fracture traces plotted on aerial photographs of the Loysville quadrangle were determined and grouped into 10-degree classes. The distribution of these groupings is shown in the semi-circular histogram in Figure 4. The fracture traces have a very pronounced N 0°–10° E trend and a somewhat less pronounced N 20°–30° W. trend.

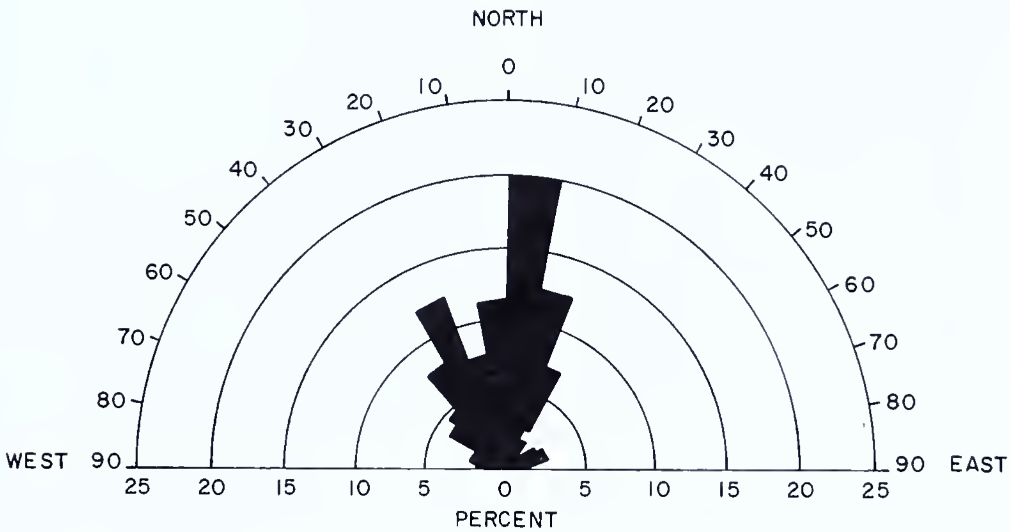


Figure 4. Semi-circular histogram showing orientation of 448 fracture traces in the Loysville quadrangle.

In the northern half of the New Bloomfield quadrangle, which adjoins the Loysville quadrangle on the east, Dyson (1963, p. 10) observed a similarly pronounced north-northeast trend (N 10°–20° E) for photographic linear features that he identified as solution trenches. These occur almost exclusively in the Tonoloway Formation (limestone). Approximately 50 miles to the northwest, in Centre County, Matzke (1961) also observed a very pronounced northerly trend of fracture traces. He also observed a minor east-west trend, which was not found in the Loysville quadrangle.

Fracture traces in the Loysville quadrangle and in western Centre County (Matzke, 1961) commonly extend across formational contacts and faults. (See Fig. 5.) In the Loysville quadrangle, a few traces cross as many as 6 or 7 formational contacts. In some places, traces extend continuously across beds of limestone, shale, and sandstone

Fracture traces are most prominently developed in the calcareous shales of the Wills Creek Formation and in the limestones of the Tonoloway and Keyser Formations. More than 70 percent of the fracture traces plotted are in these three units.

Fracture-trace and joint trends are similar in areas of gently dipping sedimentary rocks (Lattman and Nickelson, 1958; Hough, 1960; Boyer and McQueen, 1964), but one or more of the dominant trends of fracture traces may differ from those of the joints in areas of folded rocks (Matske, 1951; Lattman and Matzke, 1961; Meisler, 1963; Trainer and Ellison, 1967). Disparities between fracture-trace and joint trends occur also in the folded rocks of the Loysville quadrangle, as can be seen in comparing the histograms in Figures 3 and 4.

Northwest striking joints and fracture traces show fairly close agreement in trends, but very few joint trends are parallel to the dominant northerly trend of fracture traces. The scarcity of fracture traces that are parallel to the dominant northeast joint trend has already been explained, at least in part, from the author's effort to avoid plotting features that might be traces of bedding.

Test Wells On Fracture Traces

Two test wells, Ju-283 and Pe-466, were drilled on fracture traces in shale and limestone of the Tonoloway and Wills Creek Formations. Neither well penetrates very deeply weathered rock or rock that was extensively fractured. These results differed from those obtained in several wells drilled on fracture traces in carbonate rocks in Centre County, Pennsylvania. There, Lattman and Parizek (1964, p. 89–90) found the weathered mantle generally thicker and the occurrence of cavernous solution openings greater beneath fracture traces than beneath interfracture-trace areas. They attributed the extensive weathering to decomposition, solution and removal of rock along vertical fracture zones.

Well Ju-283 was drilled on a fracture trace in argillaceous limestone of the Tonoloway Formation at Old Port, near the southern edge of the Mifflintown quadrangle. The well is near the end of the fracture trace, which is approximately 1,800 feet long and is in the center of a small depression. (See Fig. 5.) The well is 375 feet deep, enters solid bedrock at a depth of 12 feet and penetrates only one opening more than a few inches wide. The opening is between the depths of 119 and 121 feet. It appeared to be a solution opening in a bed containing highly soluble gypsum, as the water from the zone had an exceptionally high sulfate content—more than 800 mg/l (milligrams per liter). The rock penetrated by the well was relatively soft, but firm, and showed little evidence of past fracturing and subsequent healing.

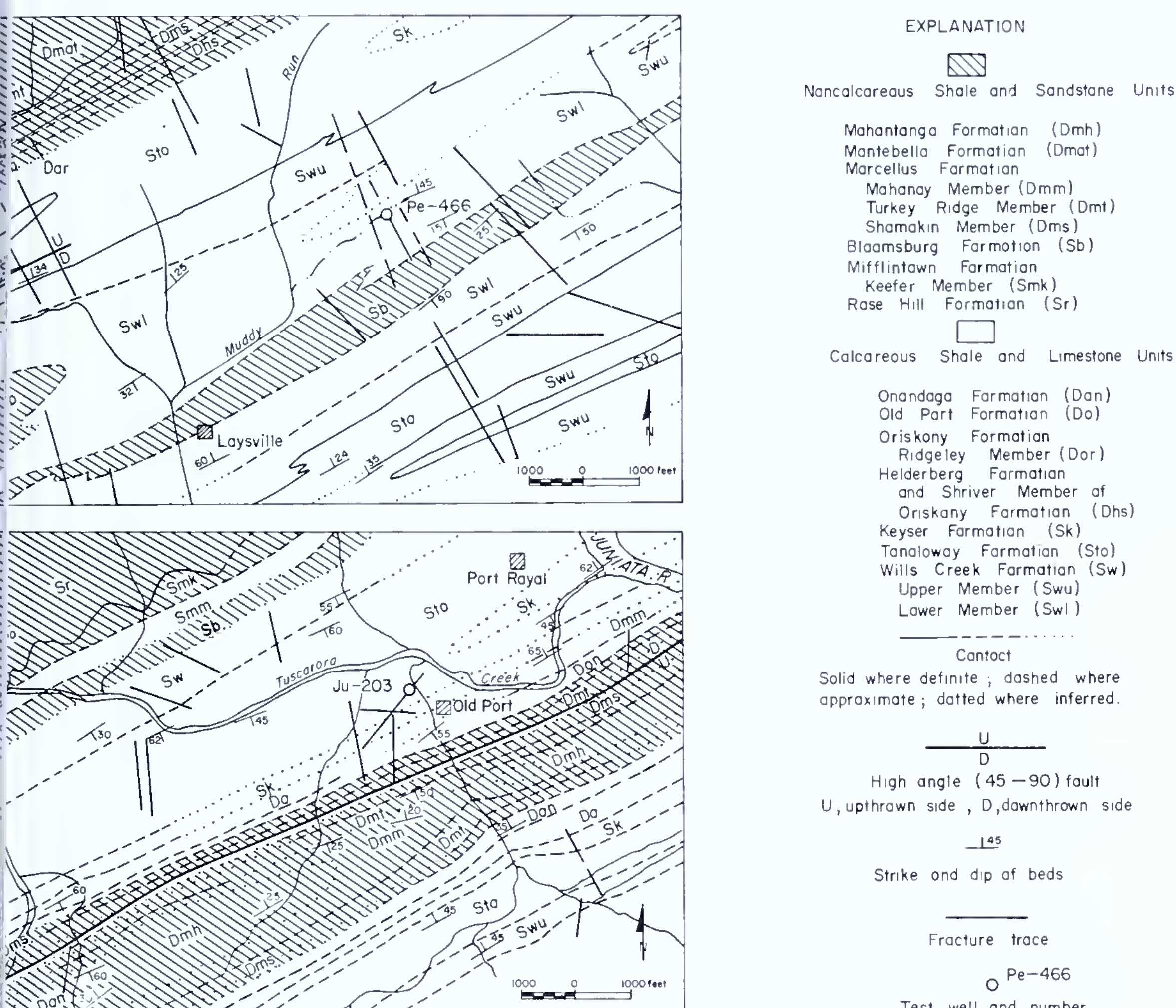


Figure 5. Geologic maps of the Loysville and Port Royal areas showing typical examples of fracture traces and locations of test wells drilled on two traces.

Well Pe-466, was drilled on a fracture trace in soft, calcareous shale of the Wills Creek Formation, approximately one mile northeast of Loysville. This well is also near the end of the fracture trace and as much as 25 feet from the center line of the fracture trace. This well is 300 feet deep, enters solid bedrock at a depth of 24 feet, and penetrates no openings more than a few inches wide. The rock penetrated by this well was firm, unfractured, and showed no evidence of past fracturing and subsequent healing.

The lithologic logs of the two test wells are given in Table 3 and their water-yielding characteristics are discussed in the section on the hydrologic significance of fracture traces.

Fracture traces may be surface expressions of vertical planes of rock weakness along which fracturing and weathering (chiefly solution) have been confined primarily to the more competent and more soluble beds. Thus, the 2-foot solution opening in well Ju-283 may be a more or less tubular opening that extends along a linear fracture zone within the highly soluble bed that was penetrated at a depth of 119 feet.

The absence of any sizable solution cavities or fractures in well Pe-466 indicates that if such openings extend laterally from a vertical fracture in the section of rock penetrated by this well they are scarce and do not extend more than a few feet from the fracture zones.

HYDROLOGY

The continuous circulation of water from the oceans—to the atmosphere—to land areas and back to the ocean, occurring over and beneath the land surface, is known as the "hydrologic cycle". The part that moves beneath the surface is the ground-water phase of the cycle, the phase with which this report is concerned.

Precipitation is the phase of the cycle that supplies fresh water to land areas, and is the source of all the naturally occurring surface and subsurface water in the Loysville and Mifflintown quadrangles. The 41 inches of annual precipitation on the study area is equivalent to about 712 million gallons per square mile. It is estimated, for a period of many years, that more than half of this amount is returned to the atmosphere by the process of evaporation and transpiration, collectively termed evapotranspiration. Most of the remainder either runs directly overland to streams, or infiltrates to the water table and percolates very slowly, through openings in the rocks, to nearby streams.

Direct runoff generally is discharged from drainage basins in the study area within a few days. Ground-water flow, however, may take months or even years to travel from points of recharge to points of discharge in a stream or other surface-water body. Thus, the openings in subsurface materials comprise a reservoir for storing water and serve to maintain streamflow by

Table 3.—Logs of test wells Ju-283 and Pe-466

WELL JU-283

Description*	Depth (feet)
Quaternary System	
Holocene Series	
Gravel, alluvial, yellowish-brown	0–12
Silurian System	
Upper Series	
Tonoloway Formation	
Shale, moderately calcareous, light olive-gray	12–20
Siltstone, moderately calcareous, olive-gray; yield zone at 37 feet (4.7 gpm)	20–50
Shale, moderately calcareous, medium gray, platy; one piece with calcite crystals	50–55
Siltstone, moderately calcareous, olive-gray	55–72
Shale, moderately calcareous, olive-gray, platy	72–75
Shale, slightly calcareous, medium-dark-gray, very platy	75–80
Shale, moderately calcareous, light-olive-gray, slightly platy, a few pieces contain finely disseminated pyrite or marcasite	80–82
Shale, very calcareous, dark gray, and siltstone, moderately calcareous, light-olive-gray; yield zone at 90 feet (14.5 gpm)	82–97
Shale, moderately calcareous, light-olive-gray; some limestone, silty, light gray, very fine-grained, granular	97–105
Shale, slightly calcareous, medium-light-gray; several pieces contain subhedral calcite crystals; yield zone at 108 feet (34 gpm)	105–110
Shale, noncalcareous, dark gray; and shale, slightly calcareous, light-olive-gray	110–119
Claystone, noncalcareous, very soft; tabular rock fragments have yellow, hematite-stained surfaces; solution opening approximately 2-feet wide is yield zone (124 gpm)	119–121
Shale, calcareous, medium-dark-gray; several pieces of vein calcite (may be from zone above)	121–130
Shale, moderately calcareous, light-olive-gray; yield increased at about 130 feet	130–135
Limestone, dark gray	135–140
Limestone, medium-light-gray	140–145
Limestone, medium-dark-gray, somewhat platy	145–150
Limestone, medium-dark-gray, platy, hard	150–172
Limestone, argillaceous, medium-gray, platy	172–180
Limestone, argillaceous, medium-gray, platy; and siltstone, calcareous, yellowish-gray; some limestone, finely laminated, small opening at 180 feet is yield zone (203 gpm)	180–197
Limestone, argillaceous, medium-gray	197–205
Limestone, medium-dark-gray	205–230
Siltstone, noncalcareous to slightly calcareous, medium-light-gray	230–235
Limestone, medium-light-gray	235–240
Limestone, argillaceous, light- to medium-light-gray; some pieces are finely laminated	240–245

Table 3.—Logs of test wells Ju-283 and Pe-466—Continued

WELL JU-283—Continued

Description*	Depth (feet)
Limestone, medium-light-gray to dark gray	245–275
Limestone, medium-gray; some pieces show fine laminations	275–290
Limestone, argillaceous, medium-light-gray, somewhat platy	290–295
Siltstone, moderately calcareous, medium-light-gray; some limestone, finely laminated	295–300
Limestone, argillaceous, light-olive-gray, laminated	300–320
Limestone, medium-gray; some vein calcite	320–330
Limestone, argillaceous, medium-gray, laminated, platy	330–335
Limestone, laminated, medium-gray	335–340
Limestone, medium-gray; a few pieces are laminated	340–345
Limestone, dark gray	345–360
Limestone, dark gray; vein calcite abundant	360–366
Limestone, medium-dark-gray	366–370
Limestone, medium-light-gray	370–375

WELL PE-466

Description*	Depth (feet)
Silurian System	
Upper Series	
Wills Creek Formation	
Lower Member	
Soil, clayey, dark-brown	0–5
Soil, clayey, dark-brown; some fragments of shale, brown	5–10
Soil, clayey, dark-brown, moist; yield zone at 24 feet (4 gpm)	15–24
Shale, grayish-green; small opening at 30 feet	24–33
Shale, red; and shale, mottled red and green	33–45
Shale, grayish-red	45–50
Shale, grayish-green; alternately hard and soft	50–55
Shale, calcareous, grayish-green	55–60
Shale, moderately calcareous, dark-gray	60–65
Shale, grayish-green	65–70
Shale, light-gray	70–72
Shale, calcareous, light-brown	72–74
Siltstone, light-brown; yield zone at 75 feet (1 gpm)	74–76
Limestone, gray, soft	76–80
Shale, slightly calcareous, light gray	80–83
Siltstone, light-brown	83–85
Shale, slightly calcareous, light-gray	85–90
Shale, noncalcareous, grayish-red	90–95
Siltstone, calcareous, grayish-red	95–100
Shale, calcareous, grayish-red	100–105
Shale, noncalcareous, grayish-red	105–109

WELL PE-466—Continued

Description*	Depth (feet)
Shale, calcareous, dark-gray	109–115
Shale, noncalcareous, light-grayish-green	115–125
Shale, noncalcareous, light-grayish-green and dark gray	125–130
Shale, noncalcareous, mottled grayish-red and grayish-green; yield zone at 131 feet (approx. 10 gpm)	130–135
Shale, noncalcareous, grayish-red and grayish-green	135–140
Shale, noncalcareous, grayish-red	140–145
Shale, noncalcareous, grayish-green, hard; yield zone at 145 feet (15 gpm)	145–150
Shale, noncalcareous, grayish-green and grayish-red	150–155
Shale, noncalcareous, grayish-red, hard	155–165
Shale, calcareous, grayish-green; some limestone, gray	165–170
Limestone, dark-gray, hard	170–180
Shale, noncalcareous, grayish-green	180–185
Shale, noncalcareous, grayish-red	185–193
Shale, calcareous, grayish-green	193–197
Limestone, dark-gray	197–205
Shale, calcareous, grayish-green	205–210
Shale, noncalcareous, grayish-green	210–211
Limestone, light-gray; yield zone at about 217 feet (25 gpm)	211–215
Shale, noncalcareous, grayish-green	215–240
Shale, calcareous, gray and greenish-gray	240–246
Shale, noncalcareous, grayish-red	246–250
Shale, noncalcareous, grayish-red and grayish-green	250–255
Shale, calcareous, grayish-red and grayish-green	255–258
Limestone, medium to dark-gray	258–270
Shale, noncalcareous, grayish-red and grayish-green	270–275
Shale, moderately calcareous, grayish-red	275–280
Shale, noncalcareous, grayish-red	280–285
Shale, calcareous, gray and grayish-red	285–290
Shale, calcareous, grayish-red, and shale noncalcareous to slightly calcareous, grayish-green	295–300

*Yields (in parentheses) are the discharges produced by the air-rotary drilling machine from the given depth.

absorbing the periodoic precipitation and returning it slowly but continuously to streams. During long periods without precipitation, the flows of unregulated streams in the Loysville-Mifflintown quadrangles are sustained entirely by drainage from the ground-water reservoir.

Relation between precipitation, ground-water levels, and streamflow, with streamflow separated into its direct runoff and ground-water runoff (baseflow) components, may be judged from Figure 6. Well Pe-212 is on a hillside in the community of Landisburg, about 5 miles southeast of the Bixler Run drainage basin. Fluctuations of water levels in this well are

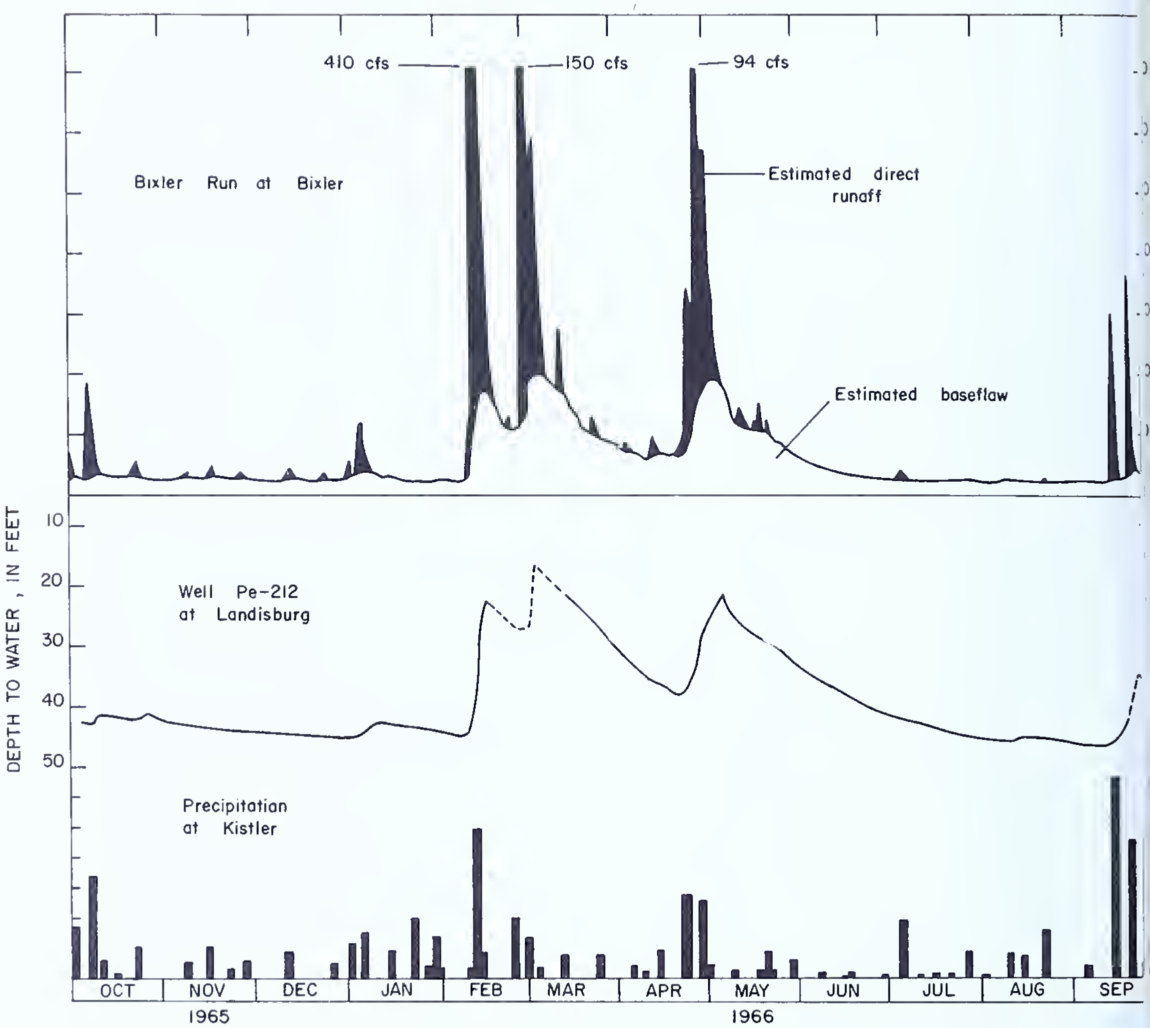


Figure 6. Graphs showing precipitation, ground-water levels, and streamflow.

typical of those in wells in similar topographic situations throughout the study area.

The graphs, showing precipitation, ground-water levels, and streamflows, are for the 1966 water year (October 1965 to September 1966), during which drought conditions prevailed. Despite overall drought conditions, above-normal precipitation during the months of January, February, and April, resulted in abundant recharge to the ground-water reservoir, as shown by the rise in ground-water runoff to Bixler Run. During the period May through August, precipitation was substantially below normal. The hydrograph of streamflow shows that only a small amount of precipitation during this period become direct runoff and that streamflow consisted almost entirely of baseflow. The fact that precipitation during late spring and summer months resulted in little recharge to the ground-water reservoir in-

dicates that most of the precipitation was either consumed by evapotranspiration or was retained by the soil to satisfy soil-moisture deficits.

WATER BUDGETS

The general disposition of the precipitation that falls on a drainage basin during a given interval of time can be shown in terms of a water-budget equation that equates total inflow to total outflow, plus or minus the net change in surface-water, ground-water, and soil-moisture storage. Over periods of several years, the net natural change in storage is usually negligible and, thus, can be ignored. The budget may be simplified further if underground inflow and outflow are assumed to be negligible. This assumption is probably correct for most basins in the vicinity of the study area, as streamflow in and near the study area is measured at points underlain by sandstone and shale that have low permeability. Thus, simplified, the equation may be expressed as:

$$\underset{\text{(Inflow)}}{P} = \underset{\text{(Outflow)}}{R + L};$$

in which,

P — precipitation on the basin,
R = stream runoff (baseflow and direct runoff),
L = water loss, resulting chiefly from evapotranspiration.

Precipitation and runoff are the factors in the budget equation that can be determined most accurately. Losses resulting from evapotranspiration cannot be measured directly for large areas and are assumed, on the basis of the simplified equation shown above, to be equivalent to the difference between precipitation and runoff.

Water budgets were computed for four basins that drain small- to moderate-sized parts of the Loysville and Mifflintown quadrangles. (See Fig. 7.) Three of the basins—those drained by Sherman, Tuscarora, and Cocolamus Creeks—are underlain by rock units that are typical of those in the study area. The fourth basin, drained by Kishacoquillas Creek, is underlain in large part by limestones and dolomites of Ordovician age that were not studied as a part of this investigation. The budget data are shown in Table 4.

Data used in the budget equations are average calendar year values for either 11 or 12 year periods. Runoff was measured at gaging stations operated and maintained by the U.S. Geological Survey. Precipitation was measured at stations in or near the individual basins. Data for Lewistown and Newport were obtained from U.S. Weather Bureau records, data for the station at Kistler were collected by the U.S. Geological Survey in conjunction with a sediment study of Bixler Run basin, which is part of the Sherman Creek drainage. Although precipitation on this mountainous region undoubtedly

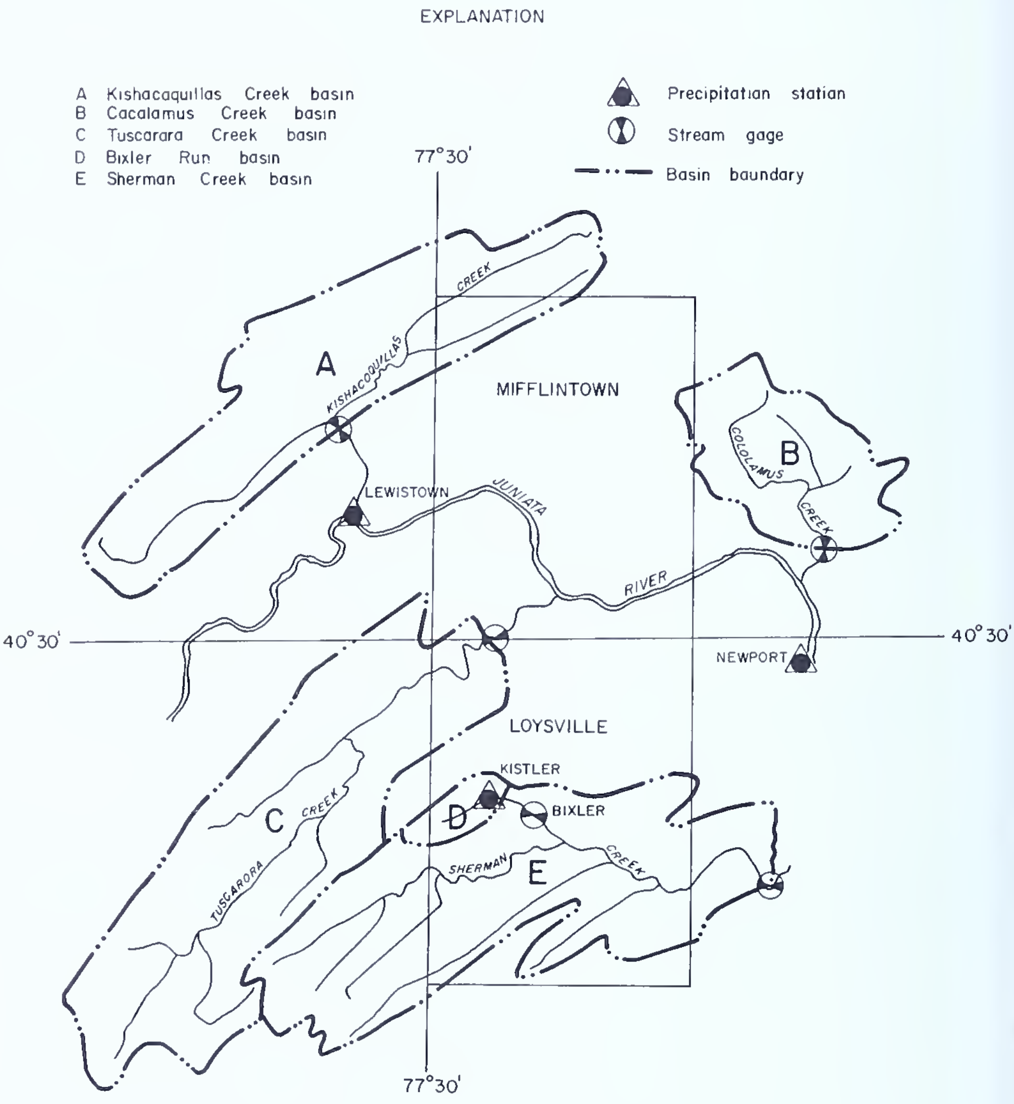


Figure 7. Map showing drainage basins for which water budget were computed.

varies substantially from place to place, the 11 to 12 year averages used are believed to be fairly representative of the long-term average precipitation on individual basins.

The budget data for the four basins indicate that 40 to 46 percent of the average annual precipitation on them leaves as streamflow; most of the remaining 54 to 60 percent is lost as evapotranspiration.

Table 4.—Basin water budgets

Basin	Area (sq mi)	Precipitation station	Years	(P) Average annual precipitation (inches)	(R) Average annual streamflow (inches)		(P-R) Average annual loss (inches)	
						(percent of precipitation)		(percent of precipitation)
Sherman Creek[1]	200	Kistler	1955–65	42.11	16.51	39.2	25.60	60.8
Tuscarora Creek	214	Newport	1948–57	41.78	17.11	40.9	24.67	59.1
Kishacoquillas Creek	164	Lewistown	1955–65	35.12	15.45	43.9	19.67	56.1
Cocolamus Creek	57.2	Newport	1948–57	41.78	19.11	45.7	22.67	54.3

[1] Includes Bixler Run basin.

BASEFLOW

The baseflow of most streams in the study area is believed to be moderately high. Baseflow determinations made for part of the Bixler Run basin, which drains an area of 15 square miles in the west-central part of the Loysville quadrangle, indicate that about 58 percent of the total streamflow consists of ground-water drainage. The rock units drained constitute a fairly representative sample of the rock units studied and include all those of Silurian age. The average annual baseflow shown in Table 5, was computed from streamflow data for the period 1955–65, and was supplied by L. A. Reed of the U.S. Geological Survey (1968, written commun.).

Despite the rather high contribution of ground water to streamflow, average well yields in the study area are low. Similar conditions of high base flow and low well yields in the Brandywine Creek basin of Chester County, Pennsylvania, were attributed to deep permeable soils, high gravity yield (short-term specific yield) from the zone of water-table fluctuation, and steep water-table gradients. The moderately high contribution of ground water to streamflow in the Bixler Run basin is believed to be due largely to the very steep water-table gradients that prevail throughout most of the basin and to a moderately high gravity yield for the zone of water-table fluctuation.

Table 5.—Average runoff from the Bixler Run basin (1955–65)

Runoff	Cubic feet per second	Inches per year	Million gallons per square mile per year	Percent of total runoff
Direct surface	6.5	5.88	102	42
Baseflow	9.0	8.16	142	58
Total	15.5	14.04	244	100

THE GROUND WATER RESERVOIR

The ground-water reservoir in the study area, as elsewhere in the unglaciated part of the Valley and Ridge Province, consists of (1) the interstitial openings in saprolite—the unconsolidated to semi-consolidated weathered rock material that mantles the bedrock—and (2) the fracture openings in the underlying and consolidated sedimentary rocks. The porosity of the saprolite is high, but its permeability is low. The porosity of the zone of open fractures in the bedrock, on the other hand, is low, but the average permeability is somewhat greater than that of the saprolite. The saprolite functions chiefly as a storage reservoir that slowly supplies water to the underlying fractures; the fractures in the bedrock function chiefly as conduits for transmitting the water from areas of recharge to areas of discharge. Where a

ground-water reservoir yields water to wells in usable quantities it is considered to be an aquifer.

Saprolite

The saprolite varies in thickness from zero at points where bedrock is exposed to as much as 50 feet beneath some hillsides that are underlain by calcareous rock units. The average thickness, as indicated by casing depths in wells, is about 35 feet beneath hillsides and about 20 feet beneath valleys. The saturated thickness of the saprolite ranges from zero beneath most ridgetops and steep slopes to as much as 20 feet in some valleys. On the basis of water-level data from a few dug wells and reports by drillers on the depths at which water was first encountered in wells, the average saturated thickness of the saprolite is estimated to be on the order of 5 to 10 feet in valleys, and less than 5 feet beneath most hillsides. The water table fluctuates several feet seasonally, and it fluctuates more on hillsides than in valleys. Thus, on some hillsides the water table may be within the saprolite in the spring and early summer, but it may drop below the bedrock surface during late summer and fall. The water table is believed to be within the saprolite throughout the year in most valleys.

Large-diameter hand-dug wells, which generally obtain most of their water from the saturated part of the saprolite, are reported to have low yields. This is an indication of the low permeability of the saprolite. Drillers also report that very little water is obtained from the saprolite as a well is being drilled through it.

The specific yield (coefficient of storage) of the saprolite was not determined, but it probably averages between 5 and 10 percent. The coefficient of storage of an aquifer is defined as the volume of water it releases from or takes into storage per unit surface area of the aquifer per unit change in the component of head normal to that surface. Water-budget studies of two areas underlain by fractured-rock aquifers in southeastern Pennsylvania have determined values of this order of magnitude for the zone of water-table fluctuation. In a basin underlain chiefly by igneous and metamorphic rocks, the gravity yield (short-term specific yield) of this zone was estimated to be between 7.5 and 10 percent (Olmsted and Hely, 1962, p. 17). In a basin underlain chiefly by carbonate rock, the specific yield was calculated to be about 5 percent (Meisler, 1963, p. 32). The water table in both areas undoubtedly fluctuates partly in the bedrock and partly in the saprolite; thus, the specific yield cannot be considered to be that of the saprolite alone. In both of these areas, as in the study area, the specific yield of the rock probably decreases as depth below the zone of water-table fluctuation increases.

If the saprolite in valleys within the study area is assumed to have an average specific yield of 5 percent and an average saturated thickness of 5 feet, the complete drainage of 1-square mile of saprolite would result in the discharge of about 52 million gallons of water from storage.

Bedrock

Fresh, unweathered bedrock is nearly everywhere highly compacted and tightly cemented, and it has few intergranular openings through which water can move. Water occurs in the bedrock chiefly in fractures (joints) or in solution cavities produced as a result of weathering along fractures in carbonate rocks. It was noted previously that joints are numerous in exposures of bedrock. Except in some of the thick, competent sandstones of the Bald Eagle, Juniata, and Tuscarora Formations, they are generally spaced less than one foot apart. Openings along most joint planes are generally no more than a fraction of an inch wide in surface exposures.

Although an entire sequence of beds may contain joints, the width, spacing, and number of joints commonly differ from bed to bed. These differences result in abrupt changes in permeability at bedding planes. The majority of joints do not extend across bedding planes, and those that do are rather widely spaced.

Evidence from several hundred drilled wells inventoried for this study indicate that the frequency and width of joint openings decreases considerably, at relatively shallow depths, below the bedrock surface. Water generally enters wells from only a few widely spaced zones, most of which yield only a few gallons per minute. These yielding zones are reported to be generally no more than a few inches thick, although openings several feet across in the vertical dimension have been penetrated by some wells drilled into limestone. The yielding zones commonly occur at bedding planes.

Analysis of yield-zone data reported for 205 wells, 84 percent of which are 150 feet or less in depth, indicates that most wells penetrate only two yielding zones. Only 16 percent of these wells were reported to have penetrated three or more yielding zones.

The frequency and size of fracture openings decrease as depth increases, owing to the weight of the overlying rock. This condition results in a corresponding decrease in the capacity of the bedrock to store and transmit water. Although water-bearing openings may exist at great depths in the bedrock, most of the openings are within a few hundred feet of the surface. The relation between depth and well yield is discussed further in a later section.

Water-level Fluctuations

Water levels in wells are continually changing in response to additions of water to, or drainage of water from, the ground-water reservoir. When recharge from precipitation or snowmelt is added to the reservoir faster than it can drain away to streams, water levels rise. When the rate of drainage exceeds the rate of recharge, water levels decline.

Hydrographs showing water-level fluctuations typical of wells in the study area are given in Figure 8. Well Ju-18 is a drilled well, 454 feet deep, in the community of Port Royal. The well is in a low-lying area underlain by the Tonoloway Formation. Well Ju-71 is a drilled well, 472 feet deep, one mile northeast of McAlisterville. The well is on a hillside underlain by the Mifflintown Formation.

Records of water-level fluctuations in these and several other wells indicate that water levels in wells in valleys can normally be expected to fluctuate through an interval of about 10 feet during each year. Water levels in wells on hillsides and hilltops can be expected to fluctuate through an interval of 20 to 30 feet.

Water levels as measured and reported for about 570 wells are listed in Table 6. The water levels are for different months and different years; therefore, as a group they should approximate average conditions. In general, water levels are relatively shallow despite the rugged topography in the study area.

WELLS

The oldest wells in the Loysville and Mifflintown quadrangles were dug by hand to depths generally less than 30 feet. A few such wells are still in use, but most have been abandoned or destroyed because of their susceptibility to bacterial contamination from on-lot sewage-disposal systems. Most wells in use are drilled wells, which were constructed either by the cable-tool or air-rotary method.

Few large-diameter wells have been drilled in the Loysville and Mifflintown quadrangles. A few municipal and industrial wells are 8 or 10 inches in diameter, but most wells are 6 inches in diameter.

Depths

The depths of 600 wells range from 25 to 870 feet, but only 57 wells are deeper than 200 feet, and 18 are deeper than 300 feet. The median depth is 90 feet. The range and median depth of wells in individual formations and members are shown in Table 7. The median depths for individual rock units range from 61 to 165 feet.

Depths of wells in most rock units average 20 to 30 feet deeper on hillsides and hilltops than in valleys and draws. The median depths in individual formations and members range from 50 to 85 feet for wells drilled in valleys and draws, and from 70 to 150 feet for wells drilled on hillsides and hilltops.

About 85 percent of the wells for which depth data are available were drilled for domestic, farm, or other low-yield requirements, for which yields of 5 to 10 gpm are generally considered adequate. Accordingly, the depths of this group of wells are indicative of the total thickness of saprolite and

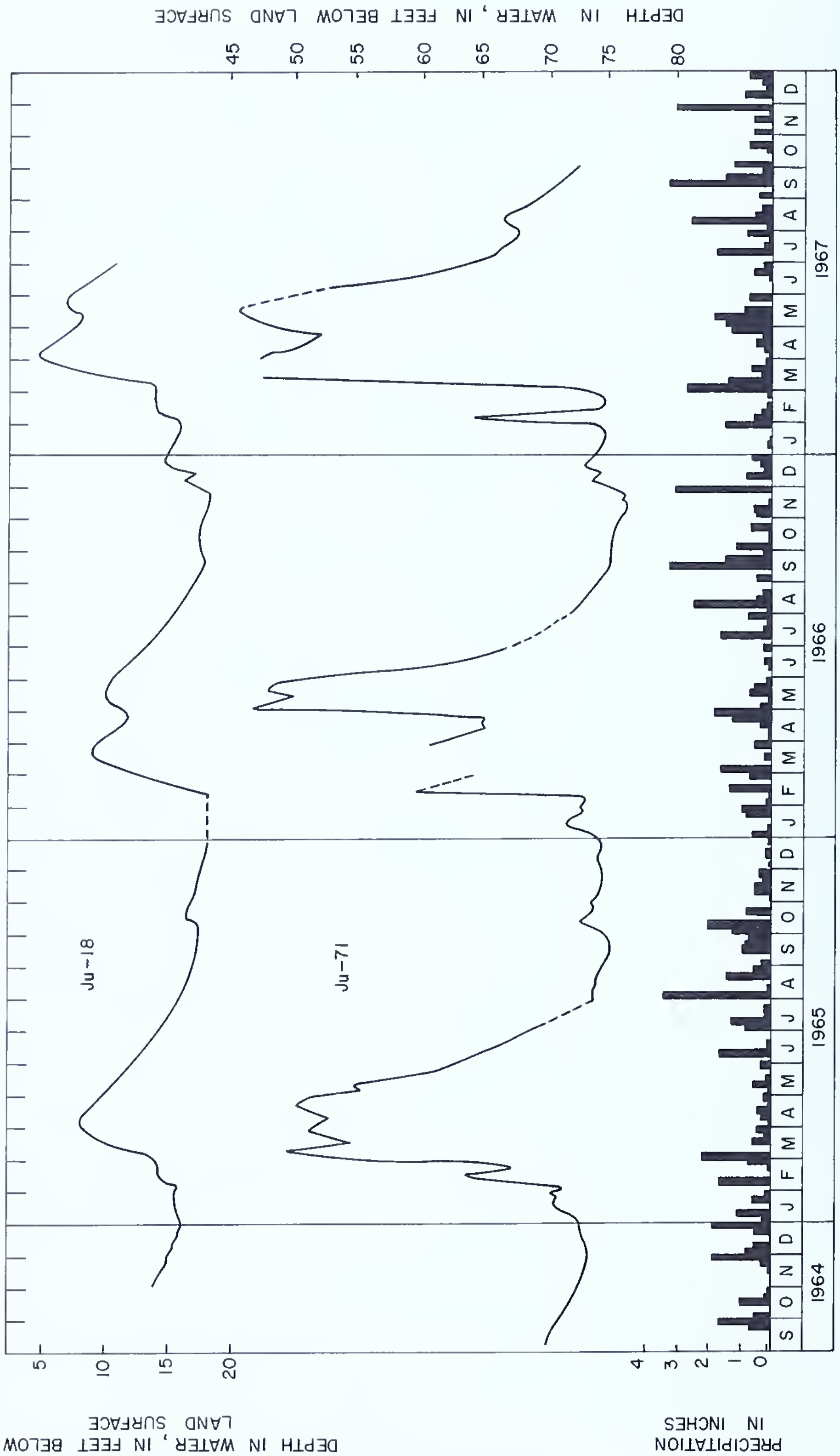


Figure 8. Typical hydrograph for wells on hillsides (Ju-71) and valleys (Ju-18), and precipitation at Newport.

Table 6—Record of wells

County well number: Wells are numbered consecutively within each of the following counties: Cu, Cumberland; Ju, Juniata; Mf, Mifflin; Pe, Perry; and Sn, Snyder.

Location number: See page 5 of the text for explanation of the location number. The first segment of the location number is from 015 to 029 for wells in the Loysville quadrangle and from 030 to 044 for wells in the Mifflintown quadrangle.

Topography: HT, hilltop; HS, hillside; D, draw; V, valley bottom.

Method of construction: Du, dug; Dr, drilled; Drc, drilled—cable tool; Drr, drilled—air rotary.

Aquifer name: Devonian Period: Dck, Catskill Fm; Dfc, Catskill-Fort Littleton transition beds; Dfm, Fort Littleton Fm; Dr, Rush Fm; Dmh, Mahantango Fm; Ds, Sherman Ridge Fm; Dmo, Montebello Fm; Dmom, Montebello Fm and Mahanoy Mbr of Marcellus Fm undivided; Dmot, Montebello Fm and Mahanoy and Turkey Ridge Mbrs of the Marcellus Fm undivided; Dmm, Marcellus Fm, Mahanoy Mbr; Dmt, Marcellus Fm, Turkey Ridge Mbr; Dms, Marcellus Fm, Shamokin Mbr; Don, Onondaga Fm; Do, Old Port Fm; Dho, Oriskany and Helderberg Fms undivided; Dor, Oriskany Fm, Ridgeley Mbr; Dhs, Helderberg Fm and Shriver Mbr of Oriskany Fm undivided.

Silurian Period: Sk, Keyser Fm; Sto, Tonoloway Fm; Sw, Wills Creek Fm; Swu, Wills Creek Fm, Upper Mbr; Swl, Wills Creek Fm, Lower Member; Sb, Bloomsburg Fm; Sm, Mifflintown Fm; Smm, Mifflintown, Fm, McKenzie and Rochester Mbrs undivided; Smk, Mifflintown Fm, Keefer Mrb; Sr, Rose Hill Fm; St, Tuscarora Fm.

Ordovician Period: Oj, Juniata Fm; Ob, Bald Eagle Fm; Or, Reedsville Fm; Om, Martinsburg Fm.

Aquifer composition: Predominant rock type reported by driller, Ch, chert; ls, limestone; sh, shale; slts, siltstone; ss, sandstone.

Static water level: +, above land surface (flowing). Reported depths are given in feet; measured depths are given in feet and tenths.

Yield: Yields for most domestic and agricultural wells were reported by the driller and are based generally on tests of less than 1-hour's duration.

Specific capacity: Values are largely for tests of short duration (1-hour or less) made at pumping rates of 3 to 25 gpm; r, values are based on data reported by driller from bailer tests of short duration (generally less than 1-hour), and on data from a few controlled pumping tests.

Use: A, agricultural; C, commercial; D, domestic; Id, industrial; It, institutional; O, observation; P, public supply; T, test; U, unused; X, destroyed.

Remarks: CA, laboratory chemical analysis; Fer, iron reported in water in bothersome or noticeable amounts; H_2S, odor of hydrogen sulfide gas present; Ll, lithologic log in table 3; YZ, depth of yielding zone in feet.

Table 6.—Record of wells

Well number	Location number	Owner	Driller	Date completed	Altitude above sea level (feet)	Topography	Method of construction	Diameter of Casing (inches)	Total depth (feet)	Depth to bottom of casing (feet)	Aquifer: Name	Aquifer: Composition	Static water level: Depth below land surface (feet)	Static water level: Date measured	Yield (gpm)	Specific capacity (gpm per ft dd)	Field measurements of water quality: Specific conductance (micromhos at at 25°C)	Hardness (grains per gal.)	Temperature (°F)	Use	Remarks
								CUMBERLAND COUNTY													
Cu-150	016-724	Colonel Denning State Park	Kohl Bros.	6-62	820	V	Dr	6	100	42	Om	sh	14.2	5-66	24	0.75r	370	9	53	It	CA
153	016-716	Sky-Hi Restaurant	David Sunday	—	1,470	HT	Dr	—	250	—	St	—	—	—	6	—	—	—	—	U	—
154	015-726	J. E. Garman	Carl Bailey	10-62	665	V	Drc	6	70	21	Om	—	7.8	3-66	15	.36	180	4	52.5	D	0.73 mg/l iron
155	015-726	Atlantic Pipeline Co.	Kohl Bros	1937	660	HS	Drc	6	166	—	Om	—	19	7-65	25	.63	335	8	55	ID,D	CA; 0.10 mg/l iron
156	016-724	Colonel Denning State Park	K. R. Whisler	—	855	V	Drc	6	107	>20	Om	—	13.4	5-66	30	1.2	190	4	51	It	0.48 mg/l iron
157	015-726	W. H. McCrea, Jr.	do.	9-46	950	HS	Drc	6	71	16	Om	—	18.1	7-65	5	.19	295	6	52	U	—
158	016-725	Colonel Denning State Park	—	—	820	V	Dr	6	91	—	Om	—	21.2	5-66	—	—	240	5	51	It	—
160	015-720	John Keller	K. R. Whisler	11-63	660	HS	Drc	6	140	47	Om	sh	30	11-63	<10	.25r	—	—	—	D	—
161	015-720	J. C. Barrick	do.	11-63	635	V	Drc	6	85	17	Om	—	10	11-63	15	1.0r	—	—	—	D	—

Table 6.—Record of wells—Continued

Well number	Location number	Owner	Driller	Date completed	Altitude above sea level (feet)	Topography	Method of construction	Diameter of Casing (inches)	Total depth (feet)	Depth to bottom of casing (feet)	Aquifer: Name	Aquifer: Composition	Static water level: Depth below land surface (feet)	Static water level: Date measured	Yield (gpm)	Specific capacity (gpm per ft dd)	Field measurements of water quality: Specific conductance (micromhos at 25°C)	Field measurements of water quality: Hardness (grains per gallon)	Field measurements of water quality: Temperature (°F)	Use	Remarks
162	015–720	George Foster	do.	4–64	625	V	Drc	6	90	26	Om	—	29	4–64	10	<.5r	—	—	—	D	—
163	015–722	Fred Burkholder	do.	8–60	650	D	Drc	6	85	42	Om	—	20	8–60	10	.6r	—	—	—	D	—
164	015–720	Leroy Foster	do.	9–55	610	V	Drc	6	70	21	Om	—	24.5	5–66	—	—	137	1	—	D	0.40 mg/l iron
165	015–720	John Chronister	do.	3–58	615	V	Drc	6	40	29	Om	—	6	3–58	>20	—	305	7	—	D	1.37 mg/l iron
167	015–720	Harry Keller	do.	12–58	655	HS	Drc	6	165	23	Om	—	16	1965	10	.25r	215	6	—	D	0.05 mg/l iron
168	016–720	John Beaston	do.	3–55	760	HS	Drc	6	87	16	Om	—	+	5–66	>10	—	200	6	52	D	0.46 mg/l iron
170	016–720	T. D. Barclay	—	—	760	HS	Drc	6	60	—	Om	—	3.8	5–66	40	3.0	178	5	54	D	0.49 mg/l iron
171	015–726	Harry Miller	—	9–51	770	HS	Du	36	15	—	Om	—	5	4–66	—	—	<30	<1	—	D	0.46 mg/l iron
172	015–719	Foster Nelson	M. L. Gayman	1–64	650	HS	Drr	6	175	81	Om	sh	55	1–64	12	—	260	8	—	D	YZ: 90, 173; 2.4 mg/l iron
173	015–718	Arthur Kech	do.	5–64	610	D	Drr	6	97	47	Om	sh	18	5–64	30	—	—	—	—	D	YZ: 75, 95.
174	015–719	Isaac Geiger	do.	7–64	650	HS	Drr	6	97	44	Om	sh	42	7–64	22	—	—	—	—	D	YZ: 68, 95
175	016–715	Earl Minnich	do.	8–65	570	HS	Drr	6	73	46	Om	sh	26	8–65	12	—	280	5	53.5	D	YZ: 70; 0.26 mg/l iron
176	015–721	Smiley Wagner	do.	11–64	655	V	Drr	6	95	45	Om	sh	28	11–64	25	—	325	8	—	D	YZ; 92; 1.0 mg/l iron
177	015–721	do.	do.	11–64	700	HS	Drr	6	73	46	Om	sh	35	11–64	12	—	—	—	—	D	YZ: 70
178	015–726	Albert Miller	K. R. Whisler	7–55	625	V	Drc	6	65	20	Om	sh	1.8	5–66	5	<.3	260	6	—	D	H_2S; 0.16 mg/l iron
180	015–726	Norman Reinford	do.	10–54	640	V	Drc	6	76	35	Om	—	+	1966	30	—	210	6	—	A,D	0.16 mg/l iron
181	015–726	Edgar Barick	do.	1953	655	V	Drc	6	88	38	Om	—	15	1953	—	—	—	—	—	D	—
182	015–726	C. D. Drum	do.	1955	670	V	Drc	6	63	15	Om	sh	10	—	<10	—	—	—	—	D	—
183	015–726	C. C. Miller	do.	8–65	690	HS	Drc	6	65	23	Om	sh	9	8–65	>15	1.0r	140	4	—	D	1.2 mg/l iron
184	015–726	F. D. Miller	do.	10–64	670	HS	Drc	6	100	47	Om	—	25	10–64	10	.3r	240	5	—	D	0.40 mg/l iron
186	016–725	Newton Landis	do.	—	780	HS	Drc	6	150	39	Om	—	8	—	<10	.25r	—	—	—	D	—
187	015–726	W. H. McCrea, Jr.	do.	8–46	890	HS	Drc	6	80	30	Om	—	24.1	7–65	—	—	—	—	—	D	—
189	016–726	Wayne Titus	—	1946	740	HS	Dr	6	100	—	Om	—	25	1965	4	.15r	200	5	—	D	0.05 mg/l iron
							JUNIATA COUNTY														
Ju- 1	031–725	H. S. Schartz	—	—	440	V	Du	48	40	—	Sto	ls,sh	34±	—	—	—	—	—	—	X	—
3	036–719	M. R. Scheibly	—	—	570	V	Dr	6	50	10	Sb	—	30±	—	<2	—	—	—	—	D	—
4	038–717	Frank Writter	—	—	660	HS	Dr	6	92	16	Sw	—	36±	—	—	—	—	—	—	D	—
6	038–716	Dr. I. G. Headings	—	—	640	V	Dr	6	46	16	Sto	ls	14±	—	—	—	—	—	—	D	—
7	038–716	C. E. Kaufman	—	—	650	V	Dr	6	75	19	Sto	—	35±	—	—	—	—	—	—	X	—
8	038–715	James Long	—	—	680	V	Dr	6	58	20	Sto	—	10±	—	—	—	—	—	—	D	—

10	035-723	Floud Britcher	—	—	530	HS	Dr	6	154	20	Swl	—	44±	—	—	—	—	—	—	X	YZ: 144
11	034-723	Eastern Milk Producers	Rittner	—	440	V	Dr	8	140	40	Sto	—	15±	—	275	—	—	—	—	C,U	CA
12	032-728	David M. Crawford	—	—	540	V	Dr	6	125	21	Sto	—	20±	—	50	—	—	—	—	D	CA
13	036-719	J. B. Wilson	Hubler	1932	580	V	Dr	6	68	10	Sb	sh	21.1	8-65	—	—	—	—	—	A,D	CA
14	032-728	D. M. Crawford	—	—	540	V	Dr	8	125	12	Sto	—	1±	—	—	—	—	—	—	D	—
15	030-725	Ralph Gilson	—	—	520	HT	Dr	6	78	20	Sk	—	42±	—	—	—	—	—	—	D	YZ: 56, 75
16	030-725	M. B. Groninger	—	—	520	HT	Dr	6	95	30	Sk	—	55±	—	<5	—	1,050	25	—	D	—
17	032-723	Breyer:Ice Cream Co.	H. K. Hornberger	—	440	V	Dr	8	263	57	Swu	sh,ls	29	—	85	1.1	—	—	—	X	YZ: 75, 100, 120, 263
18	032-723	do.	Stewart	—	440	V	Dr	8	454	18	Swu	sh	18.2	10-64	10	.14	2,100	50	54	O	—
19	032-724	William Icenburg	—	—	440	V	Dr	6	94	15	Sr	—	26±	—	—	—	—	—	—	D	—
20	033-725	Guy Stuart	—	—	480	V	Dr	6	96	28	Sto	—	38±	—	—	—	—	—	—	D	—
22	031-720	Supplee-Wills Jones Milk Co.	—	—	440	V	Dr	8	85	43	Swu	—	39±	—	80	—	—	—	—	X	Opening at 75 ft.
23	031-720	G. W. Leister	—	—	460	V	Dr	6	75	14	Swu	—	35±	—	—	—	—	—	—	D	—
25	033-716	Maynard Fenicle	A. B. Walker	—	475	V	Dr	6	60	—	Sto	—	3±	—	—	—	—	—	—	D	—
26	033-716	G. B. Wert	—	—	560	HS	Dr	6	51	40	Dmt	—	40.6	8-65	—	—	—	—	—	U	—
27	032-717	A. B. Meyer	—	—	510	V	Dr	6	95	72	Sto	sh	45±	—	6	—	—	—	—	D	—
28	032-718	R. R. Hackenberger	—	—	490	V	Dr	6	100	20	Sto	—	70±	—	—	—	—	—	—	D	—
29	034-719	J. E. Davis	—	1917	540	HS	Dr	6	137	—	Swl	sh	79±	—	—	—	—	—	—	D	—
31	033-720	W. A. Davis	—	—	460	V	Dr	6	50	28	Sb	sh	2.5	8-34	—	—	—	—	—	X	Abandoned due to red water
32	032-721	Earl Hack	C. B. Freed	—	430	V	Dr	6	47	19	Dmm	—	3±	—	4	—	—	—	—	D	H_2S
33	032-721	R. D. Henderson	—	—	510	V	Dr	6	100	42	Sw	ls,sh	52±	—	—	—	—	—	—	D,A	—
34	032-722	Samuel Bashore	—	—	560	HT	Dr	6	121	21	Sw	sh	69±	—	—	—	—	—	—	D	—
65	029-729	David Hackenberry	—	—	530	V	Dr	6	61	8	Sto	ls	15±	—	—	—	—	—	—	D	—
66	029-728	W. S. Burd	—	—	530	V	Dr	6	20	—	Swu	sh	10±	—	—	—	—	—	—	A	—
68	027-729	Thomas Hackenberry	—	—	590	V	Dr	6	58	12	Swl	sh	10±	—	—	—	—	—	—	D	—
71	038-717	McAlisterville Water Co.	—	—	730	HS	Dr	8	472	—	Sm,Sr	—	69.5	7-65	12	.11	180	3	53	O	—
72	038-716	do.	J. M. Hubler	7-53	650	V	Dr	8	210	17	Swu	ls	11	—	80	1.25r	—	—	—	P	CA
73	038-716	do.	J. M. Hubler Kohl Bros.	—	660	V	Dr	8	504	—	Sto, Swu	—	15	7-39	75	.5r	—	—	—	P	CA
74	030-722	Port Royal Municipal Authority	—	1910	672	HS	Dr	6	122	28	Swl	—	—	—	30	—	—	—	—	P	—
75	030-722	do.	—	1910	672	HS	Dr	6	92	60	Swl	—	6.0	—	50+	3.86	165	4	51	P	CA
76	030-722	do.	—	7-55	677	HS	Dr	6	62	50	Swl	—	—	—	15	—	—	—	—	P	CA
83	032-721	Earl Hack	Hubler	1934	430	V	Dr	6	50	22	Dmm	—	38	—	—	—	—	—	—	D	H_2S
84	032-721	W. E. Taylor	W. E. Hubler	10-63	450	V	Drr	6	65	28	Dms	—	18	10-63	—	—	—	—	—	D	YZ: 52, 65
86	032-721	P. C. Willard	do.	9-64	450	V	Drr	6	110	30	Dmt	sh	21.0	9-64	10	.23	325	6	54	D	YZ:30, 80, 110
87	032-721	H. E. Hack	J. M. Hubler	5-50	440	V	Drc	6	45	20	Dmt	ss,sh	8	5-50	7	—	—	—	—	D	Fer
88	032-721	T. H. Henry	do.	12-39	420	V	Drc	6	76	34	Dms	sh	26	12-39	—	—	—	—	—	D	—
90	032-719	Kelpers Esso Station	W. E. Hubler	1961	555	HS	Dr	6	175	25	Sto	ls,sh	—	—	—	—	—	—	—	D	—
91	032-720	Walker Township School	do.	—	530	HS	Dr	6	205	—	Sto	—	—	—	12	—	—	—	—	It	—
94	033-715	Thompsontown Holding Co.	J. M. Hubler	5-53	510	HS	Drc	6	135	62	Sto	—	40	5-53	14	.7r	—	—	—	Id	—
95	036-718	J. F. Schillingsford & Son	Hubler	1946	560	V	Dr	6	55	—	Smm	—	6.2	10-64	—	—	—	—	—	C	—
96	029-722	Port Royal Municipal Authority	W. E. Hubler	11-63	741	HS	Drr	6	248	—	Sb	—	31.3	6-65	16	.69	230	5	49	P	CA

Table 6.—Record of *wells*—Continued

Well number	Location number	Owner	Driller	Date completed	Altitude above sea level (feet)	Topography	Method of construction	Diameter of casing (inches)	Total depth (feet)	Depth to bottom of casing (feet)	Aquifer: Name	Aquifer: Composition	Static water level: Depth below land surface (ft)	Static water level: Date measured	Yield (gpm)	Specific capacity (gpm per ft dd)	Field measurements of water quality: Specific conductance (micromhos at 25° C)	Field measurements of water quality: Hardness grains per gal).	Field measurements of water quality: Temperature (°F)	Use	Remarks
97	029–722	do.	Hubler	—	745	HS	Dr	6	225	—	Sb	—	30.2	6–65	16	.57	260	5	49	P	—
100	033–723	St. Jude R. C. Church	J. M. Hubler	8–58	530	HS	Drc	6	303	46	Sw	sh	78	8–58	20	—	—	—	—	1t	—
101	033–723	C. D. Zimmerman	do.	7–59	570	HS	Drr	6	120	70	Sb	sh	40	7–59	15	—	265	8	—	C	—
102	033–723	C. D. Zimmerman	J. M. Hubler	4–59	580	HS	Drc	8	137	40	Sb	sh	37	4–59	16	.8r	230	6	—	C	—
103	036–724	Mifflintown Airport	do.	5–46	570	HS	Drc	6	145	28	Sto	ls	105	5–46	—	—	—	—	—	X	Pumped sand or mud
104	032–720	WJUN Radio Station	do.	7–55	480	HS	Drc	6	114	31	Sto	—	24	7–55	8	—	—	—	—	D	—
105	041–716	Lost Creek Rod and Gun Club	Shell Oil Co.	10–64	1,650	HS	Drr	10	1,650	1,514	Or	sh	<70	10–64	30	—	—	—	—	T	CA. Saltwater at 9,040 ft.
108	037–722	Lloyd Harding	Freed and Bell	5–64	800	HS	Drc	6	120	58	Sw	—	69.2	5–64	10	—	290	8	—	D	YZ: 70, 85, 110
110	039–715	Arthur Eard	M. H. Romig	7–58	790	HS	Drc	6	75	31	Smm	sh,ls	27	7–58	—	—	325	9	—	D	YZ: 50
118	035–718	Glen Stoner	G. R. Zechman	3–64	765	HS	Drr	6	297	202	Dor, Do	ls	—	—	8	—	120	5	—	D	YZ: 288; 0.38 mg/l iron
130	033–722	D. E. Smith	J. M. Hubler	7–51	518	HS	Drc	6	67	34	Sb	sh	15	7–51	—	—	—	1	—	D	—
131	033–723	W. F. Piper	do.	3–56	590	HT	Drc	5	213	40	Sw	sh	133	3–56	14	—	590	16	—	D	—
132	034–723	Max Manbeck	do.	8–41	670	HT	Drc	5	205	22	Smk, Sr	sh,ss	41	8–41	7	—	—	—	—	C	—
133	035–722	Tobe Auker	do.	5–50	600	HS	Drc	5	46	12	Sm	ss	+	—	—	—	—	—	—	D	—
134	035–722	do.	do.	12–48	600	HS	Drc	5	60	16	Sm	ss	12	12–48	5	—	—	—	—	D	—
135	033–723	Kenneth Bardell	do.	2–54	560	HS	Drc	6	115	53	Sw	sh	65	2–54	3	—	85	2	—	D,C	—
136	033–724	John Tetwiler	do.	8–39	570	HS	Drc	5	82	28	Smm	sh,ls, ss	21	8–39	5±	—	—	—	—	D	—
137	034–723	Max Manbeck	do.	6–56	670	HT	Drc	6	315	18	Smk, Sr	sh,ss	135	6–56	5	—	—	—	—	U	—
138	034–723	Larve Moist	do.	7–57	470	HS	Drc	6	86	17	Sw	ls	21	7–57	5	—	840	27	—	D	—
139	034–723	Max Manbeck	W. E. Hubler	6–65	670	HT	Drr	6	370	21	Smk, Sr	sh,ss	—	—	<1	—	510	4	—	U	—
140	029–727	H. S. Naylor	J. M. Hubler	5–42	490	HS	Drc	5	160	10	Sk	ls	48.9	8–65	15	—	825	28	—	D	—
141	030–726	Graham Robinson	do.	10–40	510	HS	Drc	6	100	10	Sto	sh	60	10–40	5	—	650	18	—	D	—
142	032–722	H. D. Renninger and Son	do.	4–41	560	HS	Drc	5	225	17	Swu	sh,ls ss	60	4–41	—	—	—	—	—	C	—

143	030-724	C. L. Goodman	do.	9-52	685	HT	Drc	4	82	72	Sk	ls	42	9-52	8	—	425	11	—	D	CA
144	030-724	Glen Kepner	do.	9-40	555	HS	Drc	5	95	22	Dmh	sh	27	9-40	5	—	100	2	52	D	Fer
145	029-723	G. S. Landis	do.	5-63	575	HS	Drc	6	55	38	Swu	—	29.6	8-65	10	—	300	8	—	D	—
146	032-722	John Bashore	do.	7-54	570	HT	Drc	5	203	20	Sw	sh	83	7-54	8	—	290	8	—	D	—
147	032-722	Gerald Clark	do.	1-40	440	V	Drc	6	52	38	Sto	sh	26	2-64	10+	—	860	24	—	D	—
148	032-724	Mrs. C. O. Telfer	do.	9-50	455	HS	Drc	5	218	20	Sr	sh,ss	30	9-50	5	—	4,000	20	—	A,D	Salty taste.
149	030-723	John Wall	do.	9-39	490	HS	Drc	6	110	27	Sto	ls	20	9-39	—	—	1,000	30	—	D	—
150	032-722	Earl Messimer	do.	10-40	455	HS	Drc	6	75	28	Sto	—	45	10-40	9	—	560	16	—	D	—
151	037-720	C. D. Smith	do.	3-41	570	HS	Drc	6	55	23	Sb	sh	8	3-41	8	—	—	—	—	U	—
152	037-720	Pine Grove Church W.S.C.S.	do.	7-53	585	HS	Drc	6	62	26	Sb	sh	7	7-53	20	1.3r	—	—	—	It	—
153	034-721	D. Q. Adams	do.	9-50	610	HS	Drc	5	180	113	Sk	ls	100	9-50	8	.4r	380	11	—	D	—
154	032-721	do.	do.	3-56	440	HS	Drc	6	69	20	Dmm	sh	9	3-56	15	1r	620	14	—	D	—
155	034-721	James Adams	do.	8-58	535	V	Drc	6	59	20	Sto	ls	9	8-58	6	—	1,420	55	—	A,D	—
157	033-723	Empire Poultry Co.	do.	12-53	490	HS	Drc	8	133	12	Sw	sh	53	12-53	45±	—	—	—	—	Id	—
158	033-723	Empire Poultry Co.	do.	3-57	490	HS	Drc	8	300	42	Sw	sh	50	12-55	45±	—	—	—	—	Id	—
159	033-723	do.	do.	3-57	490	HS	Drc	8	273	21	Sw	sh	—	—	45±	—	—	—	—	Id	-
160	034-724	R. F. Miller	do.	9-57	518	V	Drc	8	350	25	Sm	sh,ss	23	8-65	3	.1	425	11	54	D	Hole dynamited—yield not improved
161	037-718	Juniata Saddle Horse Assoc.	do.	1-65	605	V	Drc	6	48	23	Sw	sh	20	1-65	4	—	—	—	—	It	—
163	036-719	Raymond Diffenderfer	do.	6-50	570	V	Drc	6	60	27	Smm	sh	15	6-50	16	—	—	—	—	D	—
164	036-719	Ralph Shellenberger	do.	10-57	570	V	Drc	6	69	32	Smm	sh	19	10-57	15	—	—	—	—	D	—
165	031-729	John Foltz	do.	4-49	598	V	Drc	6	66	66	Sto	sh	31	4-49	5	—	496	17	—	D	—
166	031-729	Mrs. C. Gerard Smith	do.	3-47	658	D	Drc	5	65	26	Sw	sh	10	3-47	21	—	340	10	—	D	—
168	033-726	Blair Lauver	do.	5-50	560	D	Drc	6	82	16	Sw	sh	25	5-50	10	—	—	—	—	D	—
169	031-729	Stoey Lyter	do.	10-40	590	V	Drc	5	102	—	Sto	ls	37	10-40	—	—	—	—	—	D	—
170	032-728	D. M. Crawford	do.	11-39	535	V	Drc	6	101	13	Sto	ls	6	11-39	15	—	—	—	—	U	—
171	032-727	Ernest Lauver	do.	5-41	560	HS	Drc	5	127	20	Sto	ls	27	5-41	<10	—	685	20	—	D	—
172	031-729	Paul Arnold	do.	5-63	590	V	Drc	6	87	83	Sto	ls	32	5-63	17	—	470	14	—	D	—
174	029-729	Miles Imes	do.	1-51	540	D	Drc	6	68	21	Sto	sh	15	1-51	9	—	800	32	—	D	—
175	029-728	Floyd Ciccolini	do.	5-55	475	V	Drc	5	47	9	Dmom	sh	10	5-55	<1	—	150	—	—	D	Fer
176	029-729	Mrs. Mary Cooper	do.	5-50	590	HS	Drc	6	75	29	Sm	sh	23	10-50	13	.4r	385	9	—	D	—
177	029-729	Charles M. Mark	do.	7-61	720	HS	Drr	6	130	46	Sm	sh	50	7-61	10	—	—	—	—	D	—
178	028-728	Dory Stitt	do.	1-40	545	HS	Drc	6	89	12	Swl	sh	34	1-40	—	—	—	—	—	D	—
179	028-726	Walter Eichenberger	do.	12-39	620	HS	Drc	6	77	43	Swl	sh	26	12-39	5	—	—	—	—	D	—
180	028-729	Russel Boyer	do.	10-39	615	HS	Drc	5	101	35	Dmo	sh,ss	23	10-39	>30	—	—	—	—	D	Contaminated by gasoline since 1940
181	028-728	E. C. Cooper	do.	12-50	515	HS	Drc	6	89	26	Sto	sh	25	12-50							
													46.5	8-65	<5	.15r	685	19	—	D	—
182	029-726	William Stimmel	do.	1-51	620	HS	Drc	6	57	27	Sto	sh	12	1-51	10	—	—	—	—	D	—
183	034-717	Amish School	do.	7-63	630	HS	Drc	5	89	32	Do	—	54	7-63	2	—	—	—	—	It	—
184	033-718	Wilbur Ranck	do.	10-50	705	HS	Drc	5	80	17	Dmh	sh	20	10-50	3	—	—	—	—	D	—
185	033-717	Joe Hackenberger	do.	5-49	600	D	Drc	5	40	22	Dmo	ss	10	5-49	10	—	—	—	—	D	—
186	033-717	Ben Wagner	do.	7-57	610	D	Drc	6	62	22	Dmo	ss	20	7-57	9	—	—	—	—	D	—
187	033-717	D. R. Yorks	do.	5-63	650	V	Drr	6	65	—	Dmh	—	6.4	8-65	10	—	225	7	—	D	—
188	038-720	D. H. Hower	do.	8-55	740	V	Drc	6	55	20	Smm	ls,ss	10.5	8-65	10	—	215	7	—	D	—
189	038-721	C. F. Hower	do.	8-55	730	HS	Drc	6	57	20	Smm	sh,ls	14.1	8-65	<10	.34	460	11	53	D	—
190	033-719	R. A. Rowe	do.	6-40	580	HS	Drc	5	54	25	Dmt, Dmm	ss,sh	14	6-40	2	—	—	—	—	D	—

Table 6.—Record of wells—Continued

Well number	Location number	Owner	Driller	Date completed	Altitude above sea level (feet)	Topography	Method of construction	Diameter of Casing (inches)	Total depth (feet)	Depth to bottom of casing (feet)	Aquifer: Name	Aquifer: Composition	Static water level: Depth below land surface (feet)	Static water level: Date measured	Yield (gpm)	Specific capacity (gpm per ft dd)	Field measurements of water quality: Specific conductance (micromhos at at 25°C)	Field measurements of water quality: Hardness (grains per gal.)	Field measurements of water quality: Temperature (°F)	Use	Remarks
191	032–718	Centre Lutheran Church	do.	11–40	490	V	Drc	6	61	56	Sto	sh	51	11–40	—	—	—	13	—	It	—
192	033–718	Minnie Leonard	do.	10–60	655	HS	Drr	6	70	22	Dmm	sh	20	10–60	20	—	300	6	—	D	—
193	032–718	J. Zeigler	do.	4–63	500	V	Drc	6	68	24	Sk	sh	24	4–63	20	—	—	—	—	D	—
194	033–718	Charles Colyer	do.	5–64	655	HS	Drc	6	86	5	Dmh	sh	26	5–64	10	—	340	8	—	D	—
195	032–717	Blair Detra	do.	12–50	485	V	Drc	6	91	63	Sto	sh	46	12–50	8	—	—	—	—	D	—
196	032–721	E. T. Bishop	do.	12–39	450	V	Drc	6	60	36	Sw	sh	19	12–39	10	—	—	—	—	A,D	—
197	032–721	S. M. Rhine	do.	8–52	480	HS	Drc	6	128	34	Dmt	sh	28	8–52	7	—	—	—	—	D	—
198	031–719	Charles Rowe	do.	8–50	430	V	Drc	6	77	64	Sto	sh	37	8–50	6	—	—	—	—	U	—
199	032–720	John Fleisher	do.	7–58	445	V	Drc	5	86	46	Don, Dor	ss,sh	36	7–58	—	—	235	5	—	D	Fer
200	032–721	James Fill	do.	2–44	430	HS	Drc	5	65	23	Dm	sh	15	2–44	8	—	360	9	—	D	—
201	032–721	Ronald Bell	do.	1947	440	V	Drc	6	72	—	Sk	—	18.9	8–65	<5	<.1r	—	—	—	D	—
203	032–721	R. F. Hock	do.	2–42	450	V	Drc	5	70	36	Sto	sh	14	2–42	15	—	—	—	—	D	—
204	032–719	Donald Hower	do.	9–56	560	HS	Drc	6	161	—	Sto	sh	61	9–56	1	—	—	—	—	D	—
205	033–721	Janet Long	do.	4–64	440	V	Drc	6	70	41	Sb	sh	10	4–64	10	—	—	—	—	D	—
206	032–721	Ronald Bell	do.	3–47	440	V	Drc	6	59	26	Sk	sh	17.7	8–65	<10	.4	—	—	—	D	—
207	032–721	Thomas Cassett	do.	2–47	455	HS	Drc	5	70	28	Dm	sh	12	2–47	10	—	—	—	—	D	—
208	033–720	William N. Davis	do.	9–55	460	V	Drc	6	45	42	Sto	—	17	9–55	12	—	—	—	—	D	—
209	032–721	Bernheisel	do.	4–54	490	HS	Drc	5	92	77	Do	—	57	4–54	12	—	55	2	—	D	—
210	032–721	Richard Jones	do.	3–42	440	V	Drc	5	43	34	Do	ss	13	3–42	5	—	—	—	—	D	—
211	032–721	L. B. Hossler	do.	9–54	450	V	Drc	6	48	33	Dm	—	20	9–54	16	—	—	—	—	D	Very hard rock
212	032–721	J. N. Orwig	do.	3–64	490	HS	Dr	6	124	70	Sto	sh	64	3–64	11	—	—	—	—	D	—
213	032–720	Jerard Zook	do.	7–63	430	HS	Drr	6	72	19	Dmt	sh	7	7–63	2	—	310	9	—	D	—
214	032–721	Mrs. Mary Arnold	do.	3–47	425	V	Drc	5	60	30	Dms	sh	26.4	8–65	—	—	360	11	—	D	—
215	032–721	J. R. McBurney	do.	9–59	440	V	Drr	6	85	31	Dm	sh	20	9–59	5	—	280	8	—	D	—
216	032–721	R. T. Haubert	W. E. Hubler	11–63	440	V	Drr	6	57	23	Sto	ls	12	11–63	>10	—	—	—	—	D	—
217	038–715	E. C. Schell	J. M. Hubler	8–55	710	V	Drc	5	64	23	Sto	sh	18	8–55	25	—	—	—	—	D	—
218	038–717	Levi Spade	do.	9–63	725	V	Drr	6	82	—	Sr	sh	19	9–63	10	.3	170	5	—	D	—
220	038–717	E. F. Hildebrand	do.	10–51	660	V	Drc	6	82	15	Sb	sh	6	10–51	12	—	240	7	—	D	—
221	038–715	Norman Master	do.	6–64	680	V	Drc	6	76	25	Sto	sh	21	6–64	15	—	380	9	—	D	—
222	038–717	Keith Naylor	do.	6–59	660	V	Drr	6	85	18	Sw	sh	20	6–59	15	—	—	—	—	D	—
223	034–717	C. C. Ulsh	do.	5–52	565	V	Drc	5	51	20	Sw	sh	8.0	8–65	12	2.4r	330	12	—	D	—
224	037–717	J. S. G. Thompson	do.	1965	640	V	Drc	6	73	—	Swu	—	25.4	7–65	50	6.1	750	16	—	D	—
225	037–717	do.	—	—	640	V	Du	36	25.3	—	Swu	—	23.6	7–65	—	—	710	22	—	D	—
229	035–716	Noah Peachy	J. M. Hubler	5–61	660	HS	Drr	6	90	53	Sto	ls	30	5–61	15	—	—	—	—	A,D	—
230	033–715	M. R. Leach	do.	3–60	490	V	Drr	6	70	50	Sto	—	35	3–60	10	—	240	8	—	D	—

231	030-728	J. B. Groninger	do.	4-64	600	HT	Drc	6	160	19	Sw	sh,ls	80	4-64	5	—	475	12	—	D	—
232	031-726	Ida Smith	do.	9-56	610	HS	Drc	6	74	23	Smm	sh	39	9-56	30	—	350	7	52	D	CA
236	034-724	Paul Rickenbaugh	do.	9-50	530	D	Drc	5	82	6	Sb	sh	10	9-50	14	.7r	640	18	—	D	—
237	034-727	H. B. Frye	do.	9-39	510	V	Drc	6	101	27	Sto	ls,sh	6	9-39	—	—	—	—	—	D	—
239	036-725	J. E. Singer	do.	10-39	500	V	Drc	6	70	52	Sr	—	15	10-39	—	—	—	—	—	D	—
240	036-724	James Notestine	do.	5-60	560	V	Drr	6	80	21	Smm	sh	20	5-60							
													30.4	9-65	10	—	280	6	—	D	—
241	036-724	Stewart Singley	do.	3-51	500	D	Drc	6	50	25	Sb	sh	8	3-51	10	.67r	360	8	—	D	—
242	035-725	J. F. Miller	do.	5-50	625	HS	Drc	5	128	16	Sb	sh	58	5-50							
													70	60	20	—	140	3	—	D	CA
243	027-729	Frank Gray	do.	1-40	555	HS	Drc	6	61	30	Swu	ls	18	1-40	>30	—	600	19	—	D	YZ: 35
244	030-724	Paul Towsey	W. E. Hubler	1959	682	HS	Drc	6	84	20	Dmt, Dms	sh	31	1959	20	—	275	7	—	D	Fer
245	030-724	do.	—	—	585	D	Dr	6	75	—	Dmo	—	+	8-65	—	—	310	7	52	A	—
246	033-725	Russell Henderson, Jr.	J. M. Hubler	8-65	555	D	Drc	6	70	17	Sb	—	20.1	8-65	6	—	550	14	—	D	—
247	031-725	Robert Yohn	W. E. Hubler	8-65	535	HS	Drr	6	310	0	Smm	—	12.0	8-65	<1	<.1r	380	8	—	U	—
248	032-722	Earl Messimer	J. M. Hubler	1948	470	HS	Drc	6	78	—	Sto	—	49.0	8-65	—	—	—	—	—	U	—
249	033-722	C. D. Zimmerman	W. E. Hubler	6-65	695	HS	Drr	6	268	30	Smk, Sr	—	—	—	<1	<.1	240	4	54	D	—
250	034-722	C. L. Adams	G. R. Zechman	10-64	545	HT	Drr	6	197	44	Sto	—	50	10-64	7	—	430	—	54	D	—
251	032-724	Franklin Campbell	W. E. Hubler	—	455	V	Drr	6	135	15	Sr	—	20	1-64	>5	—	470	12	—	D	—
253	034-723	Earl Mahlin, Jr.	John Thran	8-65	465	V	Drc	6	81	22	Smm	—	2.0	9-65	<1	—	—	—	—	—	—
254	031-724	James Wert	W. E. Hubler	3-65	490	HS	Dr	6	90	30	Smm	—	39.8	9-65	—	—	360	9	—	D	—
255	033-726	Roy Whitesel	do.	3-60	655	HS	Dr	6	75	17	Sr	—	12	3-60	<5	<.1	165	5	—	D	—
256	033-727	R. I. Richmond	do.	1963	700	HS	Dr	6	50	35	St	—	—	—	<1	—	220	5	—	D	—
257	035-724	John Mann	do.	1960	455	V	Dr	6	75	38	Swu	—	14	3-61	15	—	500	15	—	D	Bacterially contaminated 1962
258	033-717	R. E. Saner	do.	7-65	530	HS	Drr	6	105	18	Sk	ls	25	7-65	—	—	520	18	—	A,D	YZ: 90
259	033-720	H. Dillman	J. M. Hubler	1950	460	V	Drc	6	185	>100	Sb	—	+	Spring	—	—	750	6	—	—	Cased off—H_2S water
260	034-719	C. L. Duncan	W. E. Hubler	1-64	585	HT	Drr	6	164	20	Sw	—	80	1-64	—	—	—	—	—	D	YZ: 160
261	035-715	C. O. Dimm	G. R. Zechman	1-61	735	HS	Drr	6	223	40	Sk	ls	91.8	8-65	5	<.2	870	17	53.5	D	—
262	034-721	R. I. Longacre	—	1935	530	V	Drc	6	61	—	Sto	—	24.5	8-65	—	—	—	21	—	D	—
263	035-715	C. R. Dimm	G. R. Zechman	1-61	695	HS	Drr	6	223	35	Sk	ls	85.5	8-65	5	—	430	15	—	D	—
264	037-720	Jay Sanger	W. E. Hubler	12-64	500	HS	Drr	6	110	—	Sb	—	—	—	8	—	—	—	—	D	—
265	037-718	Lloyd Fogelman	—	—	610	V	Dr	6	27	—	Sw	—	19.4	—	—	—	—	—	—	D	—
266	037-718	R. L. Seaber	M. H. Romig	1961	630	V	Drc	6	86	40	Swl	—	—	—	—	—	—	—	—	D	Reported to taste poor.
267	035-724	W. N. Quigley	W. E. Hubler	7-64	570	HS	Drr	6	180	—	Sto	—	>100	9-65	>10	—	525	14	—	A	—
268	037-724	Miles Gray	do.	7-65	645	V	Drr	6	61	—	Swl	sh,ls	12.0	9-65	25	.91	280	7	51.5	D	YZ: 18, 30, 60
269	036-728	J. D. Pecht	W. E. Hubler	6-65	465	V	Drr	6	30	32	Sr	—	31.3	9-65	10	.30	185	5	54	C	YZ: 80
270	034-723	Eastern Milk Producers	? Hubler	1938	450	V	Drc	8	150	90-100	Sto	—	28	1938	175	—	650	18	—	Id	—
278	033-719	Grant Klase	W. E. Hubler	1965	535	V	Drr	6	208	—	Dmm	—	—	—	15	—	—	—	—	D	—
280	037-718	Juniata Recreation Center	G. R. Zechman	5-66	580	V	Drr	6	72	62	Sw	sh	3.1	5-66	30	1.80	270	8	52	It	—
281	032-721	Wayne Stuber	W. E. Hubler	5-66	495	HS	Drr	6	100	48	Sto	—	59.7	6-66	6	—	—	—	—	D	YZ: 82
282	032-721	James Portzline	—	1940	480	HS	Drc	6	98	—	Sto	—	42.6	5-66	3	.26	350	11	—	D	—
283	031-723	U.S. Geol. Survey	Joseph Cekovich	6-66	423	V	Drr	6	275	26	Sto	sh,ls	8.7	6-66	200	63.4	1,700	60	54	T,O	L1
284	038-717	Paul M. Gingrich	W. E. Hubler	9-66	715	V	Drr	6	92	21	Smk	sh,ss	16.9	9-66	2	<.1	100	3	52.5	D	—
289	035-721	R. J. Richardson	J. M. Hubler	3-55	615	HS	Drc	6	53	10	Smm	sh	4.6	9-66	12	.4	55	2	55	D	—
295	035-716	Oscar Baney	W. E. Hubler	1967	780	D	Drc	6	82	27	Dms	sh	21.2	9-66	20	.88	80	1	54	U	—

Table 6.—Record of wells—Continued

Well number	Location number	Owner	Driller	Date completed	Altitude above sea level (feet)	Topography	Method of construction	Diameter of casing (inches)	Total depth (feet)	Depth to bottom of casing (feet)	Aquifer: Name	Aquifer: Composition	Static water level: Depth below land surface (feet)	Static water level: Date measured	Yield (gpm)	Specific capacity (gpm per ft dd)	Field measurements of water quality: Specific conductance (micromhos at 25°C)	Field measurements of water quality: Hardness (grains per gallon)	Field measurements of water quality: Temperature (°F)	Use	Remarks
									MIFFLIN COUNTY												
Mf- 54	042-724	Elder Will	G R. Zechman	8-58	765	HS	Dr	6	86	32	Dmt	—	—	—	—	—	—	—	—	D	CA YZ: 63, 80
55	040-723	Arthur Walters	C. B. Freed	—	730	HS	Dr	6	167	140	Do	ss,ls	127±	—	—	—	260	2	—	D	—
56	040-723	Deliah Knepp	—	1935	670	V	Dr	6	100	60	Do, Don	ss,ls	70±	—	5	—	—	—	—	U	60: ft of loose ss cased out.
58	039-727	Ralph Stirrett	—	—	565	V	Dr	6	34	15	Dmm	sh	6±	—	—	—	—	—	—	D	—
75	039-728	Max Fisher	Freed and Bell	11-62	670	HS	Drc	6	90	45	Dmm	sh	23	11-62	7	.1r	—	—	—	D	YZ: 68, 84
76	039-725	? Carter	do.	3-60	600	HS	Drc	6	75	57	Sto	ls	31	3-60	7	.2r	—	—	—	D	YZ:60
Mf- 77	040-724	Claire Boreman	do .	4-60	595	V	Drc	6	54	44	Sk	ls	27	4-60	8	0.3r	215	6	—	D	YZ: 50
78	041-727	Donald Collins	do.	5-60	690	HS	Drc	6	90	35	Don, Dms	sh	24	5-60	6	<.1r	—	—	—	D	YZ: 37, 55, 62, 84
79	039-727	D. E. Horner	do.	8-60	630	HS	Drc	6	80	30	Dmt	ss,sh	28	8-60	7	.15r	—	—	—	D	YZ: 35, 64, 72
80	039-727	Jess Yeater	do.	12-60	590	V	Drc	6	65	22	Dmm	sh	15	12-60	>20	.7r	—	—	—	D	YZ: 34, 60
82	039-727	? Rosenberry	do.	12-60	590	V	Drc	6	50±	—	Dmm	sh	22	12-60	>20	2r	—	—	—	D	YZ: 42
83	039-728	Calvin Bargo	do.	8-60	655	HS	Drc	6	80	29	Dmm	sh	16	8-60	7	.1r	230	5	—	D	YZ: 35, 66, 75
84	039-727	William Koontz	do.	1-61	695	HS	Drc	6	60	33	Dmm	sh	18	1-61	7	.2r	—	—	—	D	—
85	039-728	Richard Ritter	do.	10-64	640	HS	Drc	6	95	50	Dmm	sh	20	10-64	20±	.4r	—	—	—	D	YZ: 85
87	038-728	Lewis Snyder	do.	6-64	600	HS	Drc	6	70	57	Sto	ls	35.9	9-65	>20	2r	260	6	—	D	YZ: 62, 65
88	039-728	Albert Brower	do.	10-64	630	HS	Drc	6	100	63	Dmm	—	15	10-64	>20	1.3r	—	—	—	D	YZ: 80, 95
93	039-728	D. Wray	do.	11-63	780	HS	Drc	6	170	144	Do	ss,ls	60	11-63	10	—	240	6	—	D	YZ: 150, 165
95	039-727	Harry Durst	do.	6-62	630	HS	Drc	6	82	53	Dmm	sh	14	6-62	>20	1.2r	230	6	—	D	YZ: 70
96	038-729	D. L. Shilling	do.	4-62	630	HS	Dcr	6	100	42	Dmt	sh	25.1	9-65	>10	.1r	260	6	—	D	YZ: 60, 88, 95
101	042-725	Marling Henry	do.	9-61	780	HS	Drc	6	120	35	Don, Dms	sh	30	9-61	10	.1r	—	—	—	D	YZ: 40, 85, 110
102	040-725	Robert Davis	do.	9-61	610	V	Drc	6	90	33	Dmm	sh	10	9-61	6	.1r	—	—	—	D	YZ: 75
105	041-727	Donald Loht	do.	2-65	660	HS	Drc	6	95	68	Dms	sh	87	11-65	>20	1.3r	—	—	53	D	YZ: 91
106	039-729	J. R. Goss	do.	8-62	655	V	Drc	6	225	102	Sto	ls	70	8-62	20	1.0r	550	15	—	D,A	CA, YZ: 150, 193, 215
107	041-727	Donald Loht	do.	4-65	660	V	Drc	6	125	33	Don	sh	5	4-65	20±	.8r	—	—	—	D	YZ: 120
109	041-722	H. E. Kline	do.	3-65	780	HS	Drc	6	240	225	Do	sh	168	3-65	20±	.7r	170	5	—	D	YZ: 235
110	038-726	? Noerr	do.	9-62	622	HS	Drc	6	130	78	Sw	—	30	9-62	20±	.6r	—	—	—	D	YZ: 90, 118
111	040-726	Lee Wilt	do.	6-62	660	V	Drc	6	50	27	Dmh	sh	1	6-62	7	.15r	230	5	—	D	YZ: 46
112	040-725	Norman Shawver	do.	6-62	598	V	Drc	6	105	25	Dmm	sh	40	6-62	7	.1r	270	7	—	D	YZ: 55, 100

113	042-724	Thomas Wray	do.	1-63	720	HS	Drc	6	110	52	Dmt	sh	28	1-63	20±	.6r	—	—	—	D	YZ: 61, 69, 90
114	040-725	East Derry Sportsman's Assoc.	do.	3-63	745	D	Drc	6	140	52	Dmh	sh	60	3-63	20±	1.0r	—	—	—	It	YZ: 68, 132
115	041-725	J. W. Rupe	do.	4-63	640	V	Drc	6	50	—	Dmh	sh	42	4-63	10	1.0r	—	—	—	D	—
116	039-726	Irving Paige	do.	5-63	600	HS	Drc	6	150	62	Sto	ls	68	5-63	7	.1r	—	—	—	D	YZ: 72, 92, 132
117	040-725	Charles Marker, Jr.	do.	6-63	600	HS	Drc	6	75	28	Dmm	sh	42	6-63	20±	1.4r	—	—	—	D	YZ: 35, 50
119	039-726	Marlin Aurand	do.	12-64	723	HS	Drc	6	90	11	Dmt	ss	20	12-64	3	<.1r	—	—	—	D	YZ: 30
121	040-725	Dallas Brininger	do.	10-64	635	HS	Drc	6	140	27	Dmm	sh	35	10-64	6	.1r	—	—	—	D	—
122	039-727	Wilbut Boremand	do.	9-64	580	V	Drc	6	110	27	Dmm	sh	20	9-64	5	<.1r	215	5	—	D	YZ: 100
123	040-725	Thomas Deamer	do.	8-64	660	HS	Drc	6	150	27	Dmh	sh	40	8-64	7	<.1r	365	7	—	D	Fer, YZ: 90, 125
124	041-720	Ed Hunter	do.	6-64	730	V	Drc	6	199	22	St.	ls	30	6-64	3	<.1r	—	—	—	D	YZ: 175
125	042-723	Palmer Snook	do.	6-64	723	HS	Drc	6	70	23	Dmh	sh	24.5	11-65	>20	1.3r	140	3	—	D	YZ: 30, 40, 55, 60
126	041-724	George Kline	do.	5-64	720	HS	Drc	6	170	37	Dmh	sh	50	5-64	10	.1r	—	—	—	D	YZ: 150, 170
127	039-727	Charles Kenepp	do.	11-63	605	HS	Drc	6	100	41	Dmm	sh	35	11-63	>20	1.3r	—	—	—	D	YZ: 55, 78, 90
128	041-720	J. E. Hunter	do.	10-63	775	HS	Drc	6	145	35	Sk	—	45	10-63	7	0.1r	—	—	—	D	YZ: 40, 80,135
130	042-723	Kenneth Mowery	do.	10-63	695	HS	Drc	6	155	44	Dmh	sh	30	10-63	>20	1.0r	215	4	—	D	YZ: 88, 145
131	041-724	Neta Spigelmyer	do.	7-63	610	V	Drc	6	65	25	Dmh	sh	26	7-63	>20	1.7r	250	5	—	D	Fer
132	040-726	Foster Smith	do.	6-63	710	HS	Drc	6	125	66	Dmh	sh	38	6-63	20±	.7r	220	5	—	D	YZ:81,110, 119
133	043-723	S. C. Olnick	M. H. Romig	7-59	790	HS	Drc	6	64	20	Dmh	sh	20	7-59	>10	1.0r	—	—	—	D	YZ: 30, 60
134	042-722	Samuels U.C. C.	do.	3-62	660	V	Drc	6	90	33	Dmh	sh	32.0	9-65	20	1.04	240	2	53	It	CA, H_2S YZ: 70
135	041-721	J. H. McKnight	do.	9-60	740	V	Drc	6	65	31	Sto	ls	18	9-60	—	—	—	—	—	D	YZ: 35, 60
136	041-723	Bruce Goss	do.	1962	680	HS	Drc	6	105	14	Dmh	sh	>25	1962	—	—	210	5	—	D	—
137	041-723	Larry Marks	do.	7-61	695	HS	Drc	6	103	52	Dmh	sh	—	—	—	—	110	3	—	D	—
138	040-724	H. L. Sellers	do.	1961	710	HS	Drc	6	114	63	Do	ss,ch	32 72.2	1961 10-65	—	—	95	2	—	D	YZ: 100. Gets cloudy
139	042-723	Palmer Snook	do.	3-62	725	HS	Drc	6	59	21	Dmh	sh	12	3-62	—	—	190	4	—	D	YZ: 12, 55
140	042-722	C. E. Sheriff, Jr.	do.	12-60	670	V	Drc	6	50	22	Dmh	sh	6	9-65	>10	—	160	4	—	A,D	—
141	040-725	Charles Jones	do.	7-60	620	HS	Drc	6	80	24	Dmm	sh	9	7-60	10±	.5r	—	—	—	D	YZ: 40, 70
151	043-728	Reeds Gap State Park	L. C. Gladfelter	5-53	800	HS	Drc	6	38	34	Or	sh	22	5-53	15	.8r	—	—	—	It	H_2S, YZ: 35
152	043-728	do.	F. L. Bollinger	12-65	812	V	Drc	8	250	69	Or	sh	25.6	12-65	50	.52	160	6	49.5	It	CA, H_2S
153	043-728	do.	L. C. Gladfelter	5-53	830	V	Drc	6	65	45	Or	sh	21.0	12-65	6	.25r	—	6	50.5	It	YZ: 65
154	043-728	do.	do.	5-53	820	V	Drc	6	56	28	Or	—	11	5-53	10	.5r	—	—	—	It	YZ: 56
155	043-728	do.	do.	5-59	800	V	Drc	6	40	27	Or	—	4.9	12-65	10	.6r	230	6	49	It	YZ: 40
156	038-728	Harry Knepp	J. M. Hubler	7-60	580	V	Drr	6	80	21	Sto	ls	35	7-60	5	—	590	15	—	D	—
157	039-725	Ray Goss	do.	5-59	563	V	Drr	6	70	42	Sto	sh	5	5-59	12	—	—	—	—	D	—
159	038-727	Albert Lepley	do.	1-62	575	V	Drc	6	121	>74	Sto	ls	25	1-62	5	—	365	10	—	—	YZ: 74, 120
165	041-726	C. R. Freed	do.	10-59	765	HS	Drr	6	134	56	Do	ch,ls	54	10-59	—	—	—	—	—	D	Very hard rock
166	042-726	George Gessleman	do.	4-42	780	HS	Drc	5	87	27	Don	ls	50	4-42	7	—	—	—	—	D	—
167	042-726	Fred Sherwood	do.	4-42	800	HS	Drc	—	98	85	Do Don	—	none	4-42	0	—	—	—	—	X	No water. No solid bedrock.
168	039-727	Guy Spigelmyer	do.	12-59	575	V	Drr	6	125	42	Dmm	sh	—	—	1	—	—	—	—	D	—
169	040-727	E. H. Flood	do.	7-61	600	V	Drr	6	52	42	Dmh	sh	12	7-61	5	—	140	3	—	D	Fer
170	040-727	do.	do.	10-64	595	V	Drc	6	55	27	Dmh	sh	25	10-64	20	—	—	—	—	D	—
171	040-727	William Lepley	do.	8-59	590	V	Drr	6	80	42	Dmh	sh	40	8-59	5	—	280	6	—	D	Strong H_2S; Fer

Table 6.—Record of wells—Continued

Well number	Location number	Owner	Driller	Date completed	Altitude above sea level (feet)	Topography	Method of construction	Diameter of casing (inches)	Total depth (feet)	Depth to bottom of casing (feet)	Aquifer: Name	Aquifer: Composition	Static water level: Depth below land surface (ft)	Static water level: Date measured	Yield (gpm)	Specific capacity (gpm per ft dd)	Field measurements of water quality: Specific conductance (micromhos at 25°C)	Field measurements of water quality: Hardness grains per gal).	Field measurements of water quality: Temperature (°F)	Use	Remarks
172	041–727	L. S. Parsons	do.	12–59	665	HS	Drr	6	85	31	Dms	sh	5 16.8	12–59 11–65	4	—	435	11	—	D	Strong H_2S; Fer
176	040–725	Ralph Grabbe	do.	10–61	600	V	Drc	5	92	21	Dmm	sh	+	10–61	7	—	—	—	—	D	—
177	042–721	J. B. Hostetler	do.	2–60	645	V	Drr	6	85	20	Dmh	sh	25	2–60	5	—	—	—	—	U	—
180	041–723	Bruce Goss	Freed and Bell	5–61	665	HS	Drc	6	100	54	Dmo	sh	30.9	9–65	25	1.0	140	4	52	D	YZ: 68, 77, 92
181	041–724	J. E. Wike	G. R. Zechman	3–65	725	HT	Drr	6	147	22	Dmh	—	42	7–65	5	—	260	7	—	D	—
182	039–726	Earl Wilson	do.	1963	590	HS	Dr	6	73	—	Sto	—	13.2	9–65	—	—	—	—	—	U	—
183	040–724	G. K. Wagner	do.	9–56	755	HS	Drc	6	243	180	Sk	ls	140	9–56	5	—	330	9	—	A	Mud and sand filled seams above 180 ft.
184	040–723	do.	do.	8–58	715	HS	Dcr	6	142	130	Do	sh	30	8–58	10	—	65	2	—	D	YZ: 90, 135
185	042–726	Fred Sherwood	—	1947	800	HS	Drc	6	102	50	Don	—	88	1947	—	—	485	9	—	A,D	—
186	041–727	R. E. Wagner	M. H. Romig	1959	720	HS	Drc	6	110	110	Do	ss	42.2	11–65	<5	—	110	3	—	D	Fer, pumps sand
198	043–721	S. H. Yetter	Freed and Bell	8–65	775	HS	Drc	6	70	28	Dmh	sh	20	8–65	15	.5r	—	—	—	D	YZ: 42, 58
199	042–726	Fred Sherwood	—	—	800	HS	Du	40	31	—	Don	—	28.4	11–65	—	—	—	—	—	U	—
200	040–723	Norman Hower	G. R. Zechman	12–65	705	HS	Drr	6	243	207	Do	ss, sh,ls	122	3–66	10	.3	—	—	—	D	—
201	041–727	R. W. Wagner	do.	3–66	720	HS	Drr	6	197	167	Do	ss,ls	65	3–66	30	—	210	5	—	D	YZ: 160, 190
214	040–725	Russell Coates	Freed and Bell	6–65	597	V	Drc	6	110	39	Dmm	sh	5.5	3–66	20	.90	340	11	52	D	CA, H_2S YZ: 40, 90
219	041–726	Wesley Wiser	W. E. Hubler	11–65	750	HS	Drr	6	61	58	Do	—	38.4	3–66	10	.59	87	2	52	D	—
223	040–725	Orville Snook	Freed and Bell	10–65	615	V	Drc	6	80	41	Dmm	sh	13.2	10–65	20	.6r	—	—	—	D	YZ: 67
229	039–726	Willis Jury	W. E. Hubler	1960	600	V	Dr	6	61	—	Sto	—	5.4	4–66	40	2.6	210	7	—	U	—
								PERRY COUNTY													
Pe-45	023–718	Josiah Dunn	—	—	840	HS	Dr	6	127	50	Dhs	—	—	—	10	—	—	—	—	U	—
50	027–718	Thomas Nelson	? Walker	—	565	V	Dr	6	50	14	Df	—	1	—	20	1.0r	220	5	—	D	H_2S
52	023–725	E. M. Dobbs	—	—	700	V	Dr	6	35	24	Dms	sh	13	—	—	—	—	—	—	X	—
53	022–724	H. F. Beck	—	—	620	V	Dr	6	42	30	Don	—	—	—	10±	—	—	—	—	X	—
54	019–729	Luke Flickinger	—	—	685	V	Dr	6	51	7	Smk	ss	—	—	>12	—	—	—	—	A	—
55	021–729	Stambaugh Bros.	—	—	860	HS	Dr	6	150	17	Sto	—	—	—	1±	—	—	—	—	A,D	—
56	018–719	M. W. Morrison	? Hornberger	1931	685	HS	Drc	6	85	45	Sb	—	20	1931	15	—	160	4	—	A,D	—
58	020–718	G. K. Morrison	—	—	575	HS	Dr	6	112	67	Swl	sh	20±	—	12	—	590	16	—	D	—
59	021–718	M. H. Yohn	—	—	710	HS	Dr	6	128	90	Sto	—	90	—	7	—	350	9	—	D	—

60	021-718	Leroy Rice	—	—	650	HS	Dr	6	125	75	Swu	—	—	—	—	—	—	—	—	D	—
61	022-718	Greenpark School	—	—	600	HS	Dr	6	61	45	Swl	—	20±	—	20±	—	380	10	56	U	—
63	021-720	Keystone Area BSA	G. R. Blosser	3-26	560	V	Drc	6	95	45	Sr, Smm	—	20	—	12	—	—	—	—	X	—
64	022-720	Youth Development Center	—	—	580	V	Dr	6	102	21	Swl	ls	6	5-65	100±	>5r	—	—	—	It	CA
65	023-717	Sunnydale Farms, Inc.	G. R. Blosser	—	640	V	Drc	6	247	18	Swl	sh	15	1964	160	40r	—	—	—	C	Pumped at 100 gpm ±
67	019-716	Banks Scheibly	—	—	550	HS	Dr	15	400	40	Sb	—	+	3-65	—	—	—	—	—	U	Oil test well
69	027-715	E. Q. Meyers	—	—	530	V	Dr	6	70	16	Dck	—	8	—	20	1.67r	—	—	—	D	—
71	022-720	Youth Development Center	—	1932	615	HS	Dr	6	308	38	Swu	ls	21	1932	25±	—	—	—	—	U	CA
72	020-720	Keystone Area BSA	Kohl Bros.	8-59	620	HS	Dr	6	178	36	Sr	—	60	8-59	20	.67r	—	—	—	It	—
73	021-721	do.	do.	1962	630	HT	Dr	6	418	40	Sb	—	80	—	18	—	—	—	—	It	YZ: 90, 200
74	021-720	do.	do.	1951	560	V	Dr	6	163	5	Sr	—	20	1951	30	.36r	—	—	—	It	—
83	023-720	Dr. Joseph Matunis	do.	11-63	670	HS	Drr	6	92	40	Sto	—	13.8	7-65	—	.18	670	20	53	U	—
84	021-720	Harry Britcher	do.	9-64	560	V	Drr	6	226	27	Sr	sh	6	9-64	2	—	270	4	—	D	YZ: 41, 83
89	020-717	C. E. Bolze	do.	11-61	570	V	Dr	6	144	82	Sto	ls	15	11-61	24	1.0r	—	—	—	D	YZ: 20, 40, 140
90	020-719	J. H. Barkley	do.	9-63	530	V	Drr	6	70	43	Swu	—	9	9-63	12	—	—	—	—	D	—
91	023-717	Robert Rohrer	Robert Rohrer	9-64	720	HS	Drc	6	88	40	Swl	—	47.3	9-64	15	—	280	10	—	D	YZ: 65
92	020-718	Glen Morrison	G. R. Blosser	10-64	555	HS	Drc	6	120	37	Swl	sh	30	10-64	15	—	—	—	—	D	YZ: 50, 112
93	021-722	B. F. Lutz	do.	12-64	575	V	Drc	6	100	37	Sb	ss	10	12-64	25	—	—	—	—	D	—
94	019-716	Charles Corral	do.	11-64	540	V	Drc	6	65	45	Sb	sh,ss	15	11-64	7	—	180	5	—	D	YZ: 40, 60
95	017-716	William Barkley	do.	8-64	680	HS	Drc	6	116	25	Dmt	sh,ss	31	8-64	15	—	—	—	—	D	YZ: 58, 112
96	020-718	Robert Lynn	do.	10-64	550	HS	Drc	6	72	49	Swu	sh	10	10-64	10	—	650	18	—	D	YZ: 40, 70
97	026-719	V. E. Delaney	J. M. Hubler	10-62	575	V	Drc	6	63	27	Ds	sh	8	10-62	10	—	260	6	—	D	—
98	021-720	David Trostle	G. R. Blosser	10-64	580	V	Drc	6	60	33	Swl	sh	12	10-64	25	—	410	11	—	D	YZ: 30, 50
99	018-720	Morse	do.	9-64	680	V	Drc	6	64	34	Sb	sh	9	9-64	10	—	140	2	56	D	YZ: 60
100	018-719	Aaron Morrison	do.	8-64	705	HS	Drc	6	95	64	Sb	sh	43	8-64	30	>1.5r	210	3	—	D	YZ: 90
102	017-721	M. W. Schmoyer	do.	6-64	930	HS	Drc	6	111	25	Sb	ss	40	6-64	12	—	—	—	—	D	YZ: 70, 110
104	022-719	Brinner	do.	5-64	680	HT	Drc	6	140	62	Swl	sh	100	5-64	15	—	250	10	—	D	YZ: 75, 80, 89, 135
105	020-716	Robert Crozier	do.	5-64	590	V	Drc	6	77	50	Sto	sh,ls	8	5-64	15	—	—	—	—	D	YZ: 47, 70
107	020-718	Annie Bell	do.	12-63	565	HS	Drc	6	130	53	Swl	sh	35	12-63	6	—	1,075	27	—	D	YZ: 52, 100
108	022-719	Loysville Printery	do.	11-63	660	HS	Drc	6	132	57	Swl	sh,ls	80	11-63	12	—	—	—	—	C	YZ: 87, 125
109	022-720	L. W. Shumaker	do.	10-63	665	HS	Drc	6	125	60	Swl	sh	76.0	7-65	12	—	430	13	—	D,A	—
110	020-718	Paul Stum	do.	10-63	535	HS	Drc	6	190	28	Sb	ss	25	10-63	15	.24	270	5	—	D	YZ: 185
111	021-717	Karl Kling	do.	10-63	675	V	Drc	6	50	15	Dmt	sh	3 +	10-63 6-65	15	2.15r	190	3	—	D	Fer, YZ: 12, 30, 45
112	022-720	James Barclay	do.	10-63	615	HS	Drc	6	40	24	Sto	ls	6	10-63	15	1.5r	—	—	—	D	YZ: 10, 35
113	022-721	D. A. Scott	do.	9-63	590	V	Drc	6	80	35	Swl	sh	18.9	9-63	10	.41	450	13	54	D	FA, YZ: 65, 75
114	021-720	Ed Martin	do.	9-63	580	V	Drc	6	80	32	Sb	sh,ss	12	9-63	8	—	370	9	—	D	YZ: 70
115	020-718	Aaron Morrison	do.	8-63	580	HS	Drc	6	82	42	Swl	sh	50	8-63	25	2.5r	—	—	—	D	YZ: 75
116	019-721	W. S. Ramer	do.	8-63	630	HS	Drc	6	95	39	Sb	sh	22.3	7-65	10	.33	120	4	54	D	YZ: 85, 95
117	020-718	Kenneth Moose	do.	8-63	580	HS	Drc	6	125	39	Swu	sh	65	8-63	12	—	—	—	—	D	YZ: 85, 115
118	020-718	J. R. Shaffer	do.	7-63	540	HS	Drc	6	200	38	Sb	sh,ss	21	7-63	15	.13r	—	—	—	D	YZ: 43, 196
119	020-727	Donald Robbinson	do.	6-63	685	V	Drc	6	63	19	Sb	ss	16.8	7-65	12	—	335	8	—	D	—
121	022-718	W. W. Neely	do.	6-63	590	V	Drc	6	57	32	Swl	sh	16	6-63	15	1.5r	—	—	—	D	YZ: 55
122	019-716	Paul Crozer	do.	5-63	545	HS	Drc	6	75	29	Swl	sh	15	5-63	25	2.5r	—	—	—	D	YZ: 40, 70
123	020-717	William Fossleman	do.	5-63	580	HS	Drc	6	194	44	Sb	sh,ss	40	5-63	15	.2r	200	5	—	D	—

Table 6.—Record of wells—Continued

Well number	Location number	Owner	Driller	Date completed	Altitude above sea level (feet)	Topography	Method of construction	Diameter of Casing (inches)	Total depth (feet)	Depth to bottom of casing (feet)	Aquifer: Name	Aquifer: Composition	Static water level: Depth below land surface (feet)	Static water level: Date measured	Yield (gpm)	Specific capacity (gpm per ft dd)	Field measurements of water quality: Specific conductance (micromhos at 25°C)	Hardness (grains per gal.)	Temperature (°F)	Use	Remarks
124	019–716	Clair Camp	do.	4–63	560	HS	Drc	6	162	38	Sb	ss	21	4–63	13	.16r	210	5	—	D	YZ: 75, 162
126	021–728	David Harris	do.	11–61	700	V	Drc	6	51	31	Swl	sh	10.1	7–65	30	3.0r	550	15	—	D	YZ: 25, 38, 40
127	022–719	Elwood Hench	do.	11–61	675	HS	Drc	6	131	61	Swl	sh	96	11–61	20	2.0r	675	8	—	D	YZ: 125
128	022–718	John Hench	do.	10–61	575	V	Drc	6	51	19	Sto	ls	12	10–61	30	3.8r	—	—	—	D	YZ: 45
129	019–721	Rev. Johns	do.	6–61	690	HS	Drc	6	152	131	Swl	sh	27	6–61	15	.1r	160	5	—	D	—
130	021–719	G. G. Wilson	do.	6–61	565	V	Drc	6	118	58	Sb	ss	25	6–61	8	.1r	280	7	—	D	YZ: 60, 110
132	021–718	R. D. Linn	do.	3–62	670	HS	Drc	6	38	37	Swu	sh	20	3–62	8	.1r	—	—	—	D	YZ: 47, 95
133	019–716	Harry Crozer	do.	4–62	515	V	Drc	6	43	20	Sto	ls	16	4–62	25	6.3r	630	17	—	D	YZ: 22, 32
134	021–719	Robert Ernest	do.	5–62	590	HS	Drc	6	101	—	Sm	—	—	—	10	—	310	8	—	D	—
135	023–719	J. W. Myers	do.	5–62	775	HS	Drc	6	32	14	Dmt	ss,sh	3	5–62	15	—	390	9	—	D	YZ: 18
137	024–720	J. G. Storm	do.	6–62	630	V	Drc	6	45	17	Df	sh	+	6–62	10	1.0r	210	5	—	D	YZ: 41
138	018–716	William Barkley	do.	6–62	670	HS	Drc	6	175	21	Dmot	sh	40	6–62	15	—	430	10	52	D	YZ: 63, 172
139	020–718	Florence Wertz	do.	7–62	585	HS	Drc	6	100	63	Swl	sh	42	7–62	15	1.0r	—	—	—	D	YZ: 52, 95
140	021–725	James Kuhn	do.	7–62	620	V	Drc	6	62	20	Swl	sh	4	7–62	12	—	710	19	53	D	YZ: 20, 60
141	019–722	Leonard Sheaffer	do.	8–62	665	V	Drc	6	100	63	Sb	sh	10	8–62	15	—	230	6	—	D	YZ: 43, 35
142	020–725	C. N. Shaeffer	do.	8–62	660	HS	Drc	6	114	108	Sb	sh	40	8–62	25	—	225	6	—	D	YZ: 3
143	021–717	Raymond Peck	do.	8–60	640	HS	Drc	6	120	64	Dhs	ss	30	8–60	25	2.5r	—	—	—	D	YZ: 64, 115; filled w/coarse stone below 64 ft.
144	021–720	Joseph Morrow	do.	7–60	610	HS	Drc	6	76	63	Swl	sh	53	7–60	15	.8r	—	—	—	D	YZ: 74
145	020–717	R. N. Wilt	do.	6–60	565	V	Drc	6	86	44	Swu	sh,ls	17.8	6–65	25	.7r	400	11	—	D	CA; YZ: 120, 86;
146	020–717	Carl Bolze	do.	6–60	580	V	Drc	6	75	50	Sto	sh,ls	16.1	6–65	40	2.15	470	13	51	D	CA YZ: 65
147	018–716	Gene Womer	do.	5–60	540	V	Drc	6	51	27	Sk	—	9	5–60	30	3.0r	300	8	—	D	YZ; 35, 48
148	022–720	M. R. Emlett	do.	5–60	660	HS	Drc	6	100	55	Swl	sh	60	5–60	20	1.3r	265	8	—	D	YZ; 96
149	024–720	R. K. Weller	do.	4–60	640	V	Drc	6	57	19	Df	sh	+	4–60	7	1.0r	—	—	—	D	YZ: 24, 56
150	024–720	? Isenburg	do.	4–60	650	HS	Drc	6	59	18	Ds	sh	+	4–60	8	1.0r	—	—	—	D	YZ: 15, 57
152	020–718	Mack Wilt	do.	1–60	590	HS	Drc	6	102	37	Sw	sh	42	1–60	8	—	—	—	—	D	YZ: 70, 85
153	020–717	Frank Lyon	do.	12–59	645	HS	Drc	6	130	45	Swu	sh	72.0	6–65	15	0.3r	550	13	—	D	YZ: 103, 127
154	023–717	S. L. Henry	do.	8–59	730	HS	Drc	6	130	100	Sto	sh,ls	65	8–59	15	1.5r	—	—	—	D	YZ: 79, 128
155	019–722	Donald Lightner	do.	7–59	700	HS	Drc	6	98	40	Sb	sh,ss	37	7–59	2.5	—	70	1	—	D	YZ: 70
156	020–720	Neal Lightner	do.	7–59	535	V	Drc	6	62	38	Sto	sh	19	7–59	15	0.5r	380	39	—	D	YZ: 58
157	019–727	John Harris	do.	7–59	680	HS	Drc	6	86	36	Sb	sh,ss	20	7–59	8	0.12r	215	4	—	D	YZ: 34, 81
158	020–718	Donald Bender	do.	6–59	550	HS	Drc	6	72	50	Swu	sh	13	6–59	8	—	—	—	—	D	YZ: 37, 70
159	023–723	Harry Keller	do.	6–59	750	HS	Drc	6	75	20	Dmo	ss	40	6–53	12	0.4r	310	5	52	D	YZ: 75
160	020–718	Charles Eaton	do.	6–59	590	HS	Drc	6	110	59	Swl	sh	62	6–59	15	1.2r	—	—	—	D	YZ: 90, 105

161	020-718	Melvin Sweger	do.	5-59	650	HS	Drc	6	160	82	Swu	sh	60	5-59	6	<0.1r	510	17	—	D	YZ: 92, 130, 150
162	021-720	Joseph Wilson	do.	10-58	600	HS	Drc	6	95	52	Swl	ls,sh	37	10-58	15	0.4r	600	12	—	D	YZ: 55, 90
163	021-720	Smiley Briner	do.	10-58	615	HS	Drc	6	103	43	Swl	sh	40	10-58	8	0.16r	—	—	—	D	YZ: 50, 95
164	025-725	Jacob Shuman	do.	9-58	975	HS	Drc	6	50	21	Sr	sh	20	9-58	15	1.0r	170	4	—	D	YZ: 48
165	022-718	Edward Stambaugh	do	9-58	585	V	Drc	6	26	20	Swl	sh	39	10-58	15	1.5r	450	12	52	D	YZ: 18, 24
166	021-720	Marion Shaffer	do.	9-58	550	V	Drc	6	58	20	Sr	sh	9	9-58	9	0.2r	250	6	—	D	YZ: 40, 55
167	022-718	K. E. Kennedy	do.	9-56	600	V	Drc	6	80	38	Swu	ls	22	9-56	15	—	—	—	—	A	YZ: 40, 75
168	021-721	Wilbur Gutshall	do.	8-58	605	HS	Drc	6	100	40	Sb	ss	26	8-58	15	—	900	18	—	D	Contaminated by gasoline about 1960; now clear; YZ: 90
170	021-720	Emlet Bros.	do.	5-58	635	HS	Drc	6	100	62	Swl	sh	35	5-58	15	1.0r	400	10	—	C	CA; YZ: 158, 80, 95
171	020-718	Edward Nace	do.	5-58	575	HS	Drc	6	105	41	Swu	sh	35 65.0	5-58 6-68	>15	3.0r	720	18	—	D	YZ: 60, 90
172	026-723	Frank Minum	do.	6-57	720	V	Drc	6	95	15	Sb	sh	15	6-57	5	—	450	3	—	D	YZ: 90: Strong H_2S
173	019-726	Samuel Baltosser	do.	7-57	755	HS	Drc	6	123	24	Sb	sh,ss	35	7-57	6	.1r	180	4	—	D	YZ: 85
174	019-725	Harold Irvine	do.	7-57	660	V	Drc	6	102	46	Sb	ss	12	11-60	12	.17r	160	3	—	D	YZ: 30
175	020-715	C. A. Shope	do.	7-57	595	HS	Drc	6	70	53	Swl	sh	40	7-57	10	—	—	—	—	D	YZ: 55, 65
176	023-720	Scott Weibly	do.	7-57	785	D	Drc	6	53	21	Dmt	ss	18	7-57	10	—	150	2	—	D	YZ: 30, 50 Fer., low pH
177	023-717	Mrs. Edward Reapsome	do.	8-57	640	V	Drc	6	57	20	Sb	sh,ss	6	8-57	20	.6r	510	14	—	C	YZ: 55
179	020-718	Ward Baughman	do.	8-57	585	HS	Drc	6	109	68	Swu	sh,ls	28	8-57	15	.3r	—	—	—	D	YZ: 65, 100
180	021-728	David Harris	do.	8-57	700	V	Drc	6	53	21	Swl	sh	10	8-57	15	1.0r	—	—	—	X	YZ: 25, 48; bacterially polluted
181	019-716	Banks Scheibly	do.	9-57	560	HS	Drc	6	61	25	Sb	ss	12	9-57	8	—	—	—	—	D	YZ: 20, 55
182	023-716	C. E. Brytz	do.	9-57	735	HS	Drc	6	53	20	Don	sh,ls	5	9-57	25	2.5r	560	16	—	D	CA; YZ: 25, 50
183	021-725	Richard Johnson	do.	9-57	620	V	Drc	6	40	22	Swl	sh,ls, ss	13	9-57	20	1.7r	—	—	—	D	YZ: 25, 38
184	018-718	David McAlicher	do.	10-57	610	HS	Drc	6	80	34	Sb	sh	28	10-57	7	.2r	170	4	—	D	YZ: 75
185	019-716	Dean Shull	do.	11-57	555	V	Drc	6	89	35	Sw	sg,ss	45	11-57	15	3.0r	290	7	—	D	—
186	019-721	Paul Kiner	do.	11-57	690	HS	Drc	6	120	115	Swl	sh	15	11-57	20	2.0r	—	—	—	D	YZ: 30, 80, 115
187	024-720	Donald Lightner	do.	12-57	630	V	Drc	6	52	16	Df	sh	+	12-57	7	—	—	—	—	D	YZ: 48
188	020-718	Aaron Morrison	do.	3-56	580	HS	Drc	6	99	25	Swu	sh	35	3-56	12	1.0r	—	—	—	D	YZ: 95
189	020-718	R. J. Keefer	do.	4-56	515	V	Drc	6	70	17	Sb	ss	10	4-56	12	—	—	—	—	D	YZ: 40, 65
190	021-725	Harris Garage	do.	4-56	710	HS	Drc	6	105	49	Swu	sh	—	—	5±	—	375	39	—	C	CA, YZ: 100
191	021-718	J. S. Dum	do.	5-56	605	HS	Drc	6	62	20	Swl	sh	40	5-56	20	1.0r	330	9	—	D	YZ: 60
192	020-715	Luther Snyder	do.	5-56	575	HS	Drc	6	96	74	Swu	sh	50	5-56	10	.4r	370	11	—	D	YZ: 70
193	021-722	G. M. Clouse	do.	6-56	580	V	Drc	6	110	35	Sb	ss	28	6-56	12	—	635	8	—	D	YZ: 110
194	019-718	Harry Baughman	do.	5-56	585	HS	Drc	6	139	51	Swl	sh	51	5-56	8	—	200	5	—	D	YZ: 135
196	018-716	George Crozier	do.	9-56	565	HS	Drc	6	98	71	Dhs	ls	40	9-56	12	0.5r	320	7	—	D	YZ: 90
198	019-716	Mt. Zion Church	do.	10-56	590	HT	Drc	6	80	31	Sb	ss	37	10-56	15	—	180	4	—	It	—
199	019-717	William Brennan	do.	10-56	530	HS	Drc	6	50	22	Sm	ss	12	10-56	15	—	300	8	—	D	YZ: 45
200	021-721	Dewey Baughman	do.	11-56	555	V	Drc	6	65	36	Swl	sh	12	11-56	15	—	280	7	—	D	YZ: 34, 63
201	024-718	J. E. Stone	do.	8-57	710	V	Drc	6	73	18	Ds	sh	5	8-57	20	.5r	—	—	—	D	YZ: 25, 68
202	020-718	G. R. Blosser	do,	6-56	545	V	Drc	6	112	35	Swl	sh	20.4	9-66	20	.42	800	19	54	D	YZ: 100

Table 6.—Record of wells—Continued

Well number	Location number	Owner	Driller	Date completed	Altitude above sea level (feet)	Topography	Method of construction	Diameter of casing (inches)	Total depth (feet)	Depth to bottom of casing (feet)	Aquifer: Name	Aquifer: Composition	Static water level: Depth below land surface (feet)	Static water level: Date measured	Yield (gpm)	Specific capacity (gpm per ft dd)	Field measurements of water quality: Specific conductance (micromhos at 25°C)	Field measurements of water quality: Hardness (grains per gallon)	Field measurements of water quality: Temperature (°F)	Use	Remarks
204	021–724	J. C. Bishop	J. M. Hubler	5–61	610	V	Drr	6	170	22	Swl	sh	15	5–61	8	—	—	—	—	D	—
205	020–718	Landisburg Reformed Church	G. R. Blosser	7–65	555	HS	Drc	6	85	37	Swl	sh	32.2	7–65	20	.79	550	13	53	It	YZ: 65
208	017–721	Asper Russel	Asper Russel	1962	860	V	Drc	6	91	—	Smm	—	—	—	—	—	80	2	54	D	—
211	018–716	J. M. Sweger	G. R. Blosser	6–65	615	HS	Drc	6	70	40	Dmot	sh	24.4	6–65	15	1.12	105	3	—	D	YZ: 45, 65
212	020–718	Edward Nace	do.	—	585	HS	Drc	4	107	—	Swu	—	41.1	6–65	—	—	—	—	—	O	Contaminated by gasoline
214	021–717	J. F. Bolze	—	—	630	HS	Du	40	29	—	Sto	—	23.8	6–65	—	—	—	—	—	O	—
218	018–725	Squirrel Nest Cabin	—	—	920	HS	Du	36	39	—	Sb	—	33.5	6–65	—	—	—	2	53	D	—
219	020–718	M. W. Lightner	G. R. Blosser	7–65	525	V	Drc	6	55	23	Sb	ss	8.2	7–65	12	.68	210	5	52	D	YZ: 22, 50
221	021–720	Perry County Home	—	—	590	V	Dr	—	64	—	Swu	—	—	—	—	—	450	15	—	It	Serves 30 people
222	021–720	do.	—	—	575	V	Dr	4	124	21	Swu	—	8.8 14.8	8–65 7–65	20	.68	540	14	51	U	—
223	022–722	C. I. Noss	J. E. Hockenberry	—	605	V	Drc	6	70	26	Sto	—	—	—	15	—	530	14	—	D	YZ: 37, 65; 5 gpm at 37 ft.
224	022–723	Shelly Zendt	Kohl Bros.	1960	620	V	Drc	6	—	60	Don	—	—	—	20	—	475	11	—	D	—
225	022–725	Oscar Ricedorf	do.	1–58	830	HS	Drc	6	155	95	Dhs	—	58	1–58	4	—	270	7	—	D	YZ: 60, 94
226	022–725	J. D. Milligan	do.	1963	865	HS	Drr	6	318	34	Dhs	—	—	—	4	—	—	—	—	D,A	YZ: 165, 276, 302
227	023–724	R. B. Thrush	W. E. Hubler	1960	685	D	Drr	6	68	20	Dmt	—	1	1960	30	—	100	1	—	D	Fer. Most water at 65 ft.
228	023–726	Clair McMillan	do.	1965	688	V	Drr	6	80	—	Don	—	—	—	8	—	740	17	—	D	—
229	022–728	R. E. McMillen	do.	1963	765	V	Drr	6	80	18	Sto	sh,ls	8	10–63	>50	—	255	6	—	D,A	YZ: 18, 55; 25 gpm at 18 ft.
230	024–725	L. D. McMillen	do.	1963	723	V	Drr	6	170	20	Sto	—	10.1	7–65	22	.34	515	15	55	D,A	Fer. no water above 150 ft.
231	023–725	Theodore Latchford	Jack Walker	1963	700	HS	Drc	6	43	13	Dms	sh,ls	10	9–63	10	—	300	7	—	D	YZ: 41
232	023–725	Harry Latchford	do.	1963	720	HS	Drc	6	93	50	Dms	sh	18	9–63	10	—	120	2	—	D	Fer
233	022–724	Raymond Kint	W. E. Hubler	1960	670	V	Drr	6	35	35	Dor	—	6	12–64	>20	—	60	1	—	D,A	Loose yellow sand
234	026–722	C. K. Reisinger	Joseph Cekovich	1965	745	HT	Drr	6	225	23	Sb	slts, sh	35	3–65	8	—	435	11	—	C	YZ: 225; no water above 225 ft.

235	026-722	do.	W. E. Hubler	1965	720	HT	Drr	6	165	20	Sb	sl,st, sh	45.6	8-65	<1	<.1	340	8	53	D	Hole dry above 140 ft.
236	026-723	P. Stuber	do.	1961	750	HS	Drr	6	60	16	Sb	—	5	12-61	16	—	—	5	—	D	8 gpm at 45 ft; YZ: 45, 58
238	023-726	Robert Wagner	do.	1965	675	V	Drr	6	46	17	Dms	—	3.6	8-65	15	.56	370	10	53	C	YZ: 35
239	023-726	do.	do.	1965	675	V	Drr	6	61	20	Dms	—	3.2	8-65	8	—	—	—	—	C	Cased off at 18 ft.
240	025-723	C. H. Swartz	Earl Walker	1947	790	HS	Drc	6	235	52	Dhs	ls,ss	126	1947	>20	—	315	9	—	D,A	Little draw-down reported
241	025-723	do.	W. E. Hubler	1959	790	HS	Drr	6	150	50	Dhs	ls,ss	114.7	8-65	<1	<.1	—	—	—	—	—
242	023-726	J. E. Dobbs	—	—	690	V	Du	—	16	—	Dms	—	9.3	9-65	—	—	—	—	—	O	—
244	026-719	V. E. Delaney	J. M. Hubler	1965	575	V	Drc	6	47	—	Dr	—	6.5	7-65	15	.55	255	6	52	D	H_2S
246	022-715	? Kistler	—	—	965	HS	Du	40	29	—	Dmt	—	26.1	7-65	—	—	190	4	51	D	—
247	022-716	do.	—	—	940	HS	Du	40	29	—	Dms	—	13.5	7-65	—	—	—	—	—	D	—
248	022-716	? Kistler	—	—	955	HS	Du	36±	21.5	—	Dms	—	9.8	7-65	—	—	—	—	—	U	—
249	024-716	J. D. Stambaugh	Kohl Bros.	1959	770	HS	Drc	6	300	45	Sto	—	30	8-59	20	—	910	23	—	A	—
251	024-715	Arthur Dum	—	1964	748	HS	Dr	6	97	—	Swu	—	21.3	7-65	—	—	510	11	—	D	—
255	024-716	H. R. Radle	Joseph ceko-vich	1965	825	D	Drr	6	123	30	Dmt	—	30.8	7-65	15	.31	110	2	51.5	D	Fer
257	022-720	W. N. McGowan	G. R. Blosser	1951	830	HT	Drc	6	403	51	Sk	ls	—	—	8	—	—	—	—	D	—
258	022-721	R. K. Alleman	J. E. Hocken-berry	1962	750	D	Drc	6	45	—	Dmt	—	—	—	30±	—	—	—	—	D	Fer
260	023-721	S. J. Weibly	W. E. Hubler	1964	835	HS	Drr	6	78	20	Dmot	—	—	—	—	—	—	4	—	D	—
261	028-716	K. J. Knisely	Earl Walker	1940	745	HT	Drc	—	100	—	Df	sh	—	—	9±	—	190	3	—	D	CA
263	029-715	R. R. McNaughton	do.	1943	690	V	Drc	6	42	15	Dr	—	+	1943	20	—	220	4	—	D	H_2S
264	028-716	C. E. Burd	do.	1938	690	D	Drc	6	55	—	Df	—	16.5	8-65	—	—	240	4	—	D	—
265	029-715	J. W. Burd	—	—	725	HS	Du	36	22	—	Ds	—	12.2	8-65	<5	—	—	—	—	D	Has been pumped dry.
270	025-715	D. P. Radle	—	—	720	HS	Du	36	28	—	Ds	—	—	—	—	—	180	3	—	D	Bacterially polluted.
271	026-719	C. A. Knouse	Earl Walker	1950	635	HS	Drc	—	35	—	Ds	—	+	1950	—	—	—	4	—	D	—
272	026-719	do.	W. E. Hubler	1965	580	V	Drr	6	60	18	Ds	—	30	7-65	12	—	150	3	—	D	CA
273	027-718	Mrs. George Long	Jack Walker	1962	590	HS	Drc	6	187	—	Ds	sh	—	—	12	—	—	—	—	D	—
274	027-718	F. S. Crum	—	—	590	HS	Du	36	28	—	Ds	—	22.8	8-65	—	—	—	3	—	D	H_2S
276	027-716	K. R. Stone	G. R. Blosser	1951	575	V	Drc	—	70	25	Df	—	20	1951	8	—	160	3	—	D,A	—
277	027-718	C. W. Newlin	Joseph Ceko-vich	1965	580	V	Drr	6	140	20	Ds	sh	+	6-65	6	0.2r	210	4	—	D	YZ: 100, 140
278	028-717	Mrs. Edward Paden	Earl Walker	1948	625	HS	Drc	6	54	28	Ds	—	10	1948	20	—	220	5	—	D	YZ: 45, 54
279	028-717	M. A. Metz	Shiffert Bros.	1960	650	HS	Drc	6	104	80	Ds	—	10	1960	12	—	170	3	—	D	Fer
280	028-716	E. A. Swartz	Earl Walker	1955	660	V	Drc	6	88	20	Ds	—	+	1965	—	—	—	—	—	D	—
281	028-716	C. L. Shotzberger	W. E. Hubler	1960	710	HS	Drr	6	60	16	Ds	sh	5	1965	35	—	—	—	—	D	—
282	025-715	J. A. Corman	Shiffert Bros.	1965	700	HS	Drc	6	70	25	Ds	sh	8.1	7-65	10	—	200	4	—	D	—
283	025-716	S. G. Urick	Earl Walker	1957	695	V	Drc	6	80	18	Dr	—	—	—	18	—	200	4	—	D	CA
284	026-717	G. H. Haas	do.	—	830	HS	Drc	6	77	—	Dfc	—	22.2	7-65	<3	—	245	5	—	D	—
285	027-718	P. G. Reisinger	Jack Walker	1962	570	V	Drc	6	60	—	Dr	—	+	9-62	40	—	—	—	—	U	YZ: 40, 60; strong H_2S
286	027-718	do.	—	—	570	V	Du	—	12	—	Dr	—	9	1964	—	—	340	4	—	D	Has never gone dry.
287	027-718	J. L. Bailor	Earl Walker	—	570	V	Drc	6	30	20	Ds	—	+	—	—	—	—	—	—	D	H_2S
288	027-717	W. E. Britcher	do.	1945	600	HS	Drc	6	87	20	Ds	—	<20	—	—	—	—	—	—	D	—
290	027-719	W. C. Deatrick	—	1959	750	HS	Dr	6	208	80	Sto	—	25	1964	8	—	—	—	—	D	YZ: 22; no water below 22 feet.

Table 6.—Record of wells—Continued

Well number	Location number	Owner	Driller	Date completed	Altitude above sea level (feet)	Topography	Method of construction	Diameter of casing (inches)	Total depth (feet)	Depth to bottom of casing (feet)	Aquifer: Name	Aquifer: Composition	Static water level: Depth below land surface (ft)	Static water level: Date measured	Yield (gpm)	Specific capacity (gpm per ft dd)	Field measurements of water quality: Specific conductance (micromhos at 25°C)	Field measurements of water quality: Hardness grains per gal).	Field measurements of water quality: Temperature (°F)	Use	Remarks
293	023-717	L. E. Sledzinski	—	—	670	HS	Dr	6	65	—	Swu	—	20	1961	—	—	—	—	—	D,A	—
295	025-719	R. L. Fooce	—	—	915	HT	Dr	—	237	—	Df	—	40	1964	—	—	—	—	—	D	—
296	025-717	E. S. Comp	Jack Walker	—	810	HS	Drc	6	185	80	Df	—	—	—	6	—	—	—	—	D	—
297	026-718	Mrs. Ralph Jacobs	J. E. Hocken-berry	—	635	V	Drc	—	68	—	Df	—	—	—	21	—	280	3	—	D,A	—
298	026-717	R. K. Brinton	Jack Walker	1963	825	HS	Drc	6	350	25	Df	—	41.9	8-65	10	—	—	—	—	A	—
299	018-719	M. W. Morrison	—	—	685	HS	Du	—	21	—	Sb	—	—	—	—	—	200	2	52	D	Goes dry in August
300	020-717	William Barkley	G. R. Blosser	1965	570	HS	Drc	6	118	77	Sb	ss,sh	43	1965	25	2.0r	—	—	—	D	YZ: 66, 105
305	027-721	M. A. Snyder	Jack Walker	1958	625	V	Drc	6	211	18	Sto	ls	6	7-58	9	—	860	24	—	D	—
307	024-727	M. L. Shaeffer	Joseph Ceko-vich	1964	1,055	HS	Drr	6	139	68	Sr	—	26.0	8-65	10	.15	210	5	49.5	D	—
308	024-727	do.	do.	1965	995	HS	Drr	6	73	48	Sr	—	25	1-65	12	—	—	—	—	D	—
309	024-727	Lindsay Depaw	do.	1964	970	HS	Drr	6	117	43	Sr	—	15	5-64	25	—	160	4	—	D	CA, Fer
310	024-727	Edward Bichart	do.	1964	940	HS	Drr	6	92	67	Sr	—	10	5-64	20	—	—	—	—	D	—
311	024-727	M. L. Sheaffer	do.	1964	1,005	HS	Drr	6	117	67	Sr	—	20	5-64	10	—	—	—	—	D	—
312	024-727	do.	do.	1965	1,020	HS	Drr	6	160	67	Sr	—	35	1-65	4	—	—	—	—	D	—
313	024-727	Truman Sminkey	do.	1964	980	HS	Drr	6	142	67	Sr	—	—	—	3	—	—	—	—	D	—
314	024-726	Mesemer	do.	1964	1,020	HS	Drr	6	92	62	Sr	—	—	—	12	—	—	—	—	D	—
315	024-726	Joseph Sweeney	do.	1964	1,020	HS	Drr	6	125	63	Sr	—	—	—	10	—	—	—	—	D	Fer
316	024-726	K. W. Worley	do.	1964	950	HS	Drr	6	90	45	Sr	—	20	10-64	35	—	—	—	—	D	—
319	029-716	Burt Hahn	W. E. Hubler	—	645	D	Drr	6	72	20	Dmm	—	+	—	10	—	—	—	—	D	—
320	029-716	George Schlitzer	do.	—	655	D	Drr	6	65	20	Dmm	—	—	—	7	—	—	—	—	D	—
322	029-716	Mrs. Stone	Shiffert Bros.	—	655	HS	Drc	6	35	—	Dmo	—	—	—	—	—	—	—	—	D	—
323	029-717	Charles Rathfon	W. E. Hubler	—	1,020	HS	Drr	6	200	—	Dmo	—	125	—	3	—	—	—	—	D	—
324	029-716	Merle Lehmer	do.	—	910	HS	Drr	6	50	20	Dmo, Ds	—	+	—	15	—	160	4	—	D	0.23 mg/l iron
327	029-716	LaRoss Johnson	do.	—	950	HS	Drr	6	150	20	Ds, Dmo	—	70	—	4	—	—	—	—	D	—
328	029-716	George Brinton	do.	—	1,000	HS	Drr	6	100	<20	Dmo	—	30	—	>5	—	—	—	—	D	—
329	029-716	Frank Jones	do.	—	1,010	HS	Drr	6	114	20±	Dmo	—	35	—	5	—	65	1	—	D	0.22 mg/l iron
330	028-716	George Mumpher	do.	—	1,040	HS	Drr	6	135	20±	Dmo	—	65	—	<3	<.1r	—	—	—	D	—
332	029-717	—	do.	—	870	HS	Drr	6	170	20±	Dmo	—	85	—	<3	—	—	—	—	D	—
333	029-717	G. A. Nulf	do.	—	930	HS	Drr	6	165	20±	Dmo	—	73	—	<3	—	55	1	—	D	0.29 mg/l iron
334	029-717	—	do.	—	810	HS	Drr	6	125	20±	Dmo	—	55	—	>5	—	—	—	—	D	—
335	029-717	George Weiser	do.	—	975	HS	Drr	6	200	20±	Dmo	—	125	—	3	—	185	4	—	D	0.23 mg/l iron
336	029-717	C. K. Baumbach	do.	—	985	HS	Drr	6	200	20±	Dmo	—	160	—	2	—	—	—	—	D	—

337	026-717	R. K. Brinton	Earl Walker	—	765	HS	Drc	—	100	—	Df	—	—	—	4	—	—	—	—	D	—
338	025-716	J. A. Peck	W. E. Hubler	1964	705	V	Drr	6	81	—	Ds	—	14.9	7-65	<1	<.1	180	4	53	D	—
339	024-716	W. B. Reisinger	Shiffer Bros.	—	830	D	Drc	6	80	30	Dmt	—	30	—	15	—	—	—	—	D	—
340	027-721	D. R. Johnson	Earl Walker	1955	640	V	Drc	6	68	41	Swu	ls	7	10-55	100	—	—	—	—	D	—
341	027-720	D. S. Sheriff	do.	1930	620	V	Drc	6	49	—	Swu	—	16.6	8-65	—	—	700	17	—	D	—
345	020-718	Landisburg V.F.W.	G. R. Blosser	—	580	HS	Drc	6	103	60	Swl	—	37.8	9-66	50	1.9	640	15	54	D	0.05 mg/l iron
346	020-718	Landisburg Elementary School	G. R. Blosser	1927	610	HS	Drc	—	78	40	Swu	—	—	—	15	—	—	—	—	It	—
347	020-718	do.	Kohl Bros.	1951	610	HS	Dr	6	232	45	Swu	—	60	9-51	30	—	—	—	—	It	—
348	022-718	West Perry School District	Ridpath and Potter	1952	645	HS	Dr	8	212	31	Swu	—	35	7-52	42	.36	—	—	—	It	CA
350	027-720	S. R. Sheriff	Earl Walker	1953	630	V	Drc	6	78	26	Swl	sh,ls	—	—	20	—	1,200	27	—	D	YZ: 63, 75
354	027-715	Walnut Grove Church	do.	—	530	V	Drc	6	50	22	Dck	—	—	—	20	—	—	—	—	It	—
356	027-721	Ickesburg Reformed Church	do.	—	640	V	Drc	6	67	20	Swu	ls	—	—	16	—	—	—	—	It	—
358	027-721	Stanley Shiffert	do.	—	630	V	Drc	6	72	39	Swu	—	—	—	30	—	—	—	—	D	—
359	027-721	Ickesburg Hotel	do.	—	630	V	Drc	6	100	28	Sto	ls	—	—	50	—	—	—	—	D	Has been contaminated by fuel oil.
361	027-721	Jesse Smith	do.	1950	640	V	Drc	6	81	25	Swu	—	—	—	30	—	—	—	—	D	—
362	027-721	Lutheran Parsonage	do.	—	640	V	Drc	6	61	27	Swu	—	—	—	18	—	—	—	—	D	—
364	027-718	? Sheaffer	do.	—	595	V	Drc	6	52	23	Ds	—	—	—	50	—	—	—	—	D	—
367	027-718	Eschol Schoolhouse	do.	—	585	D	Drc	6	32	24	Ds	—	—	—	8	—	—	—	—	D	—
368	025-717	Dale Haas	do.	—	800	HS	Drc	6	72	14	Ds	—	—	—	16	—	—	—	—	D,A	—
369	024-717	Marlin Rudy	do.	—	765	HS	Drc	6	57	26	Ds	—	—	—	11	—	—	—	—	D,A	—
372	025-716	Russel Cristman	Joseph Cekovich	1964	920	HT	Drr	6	225	40	Dmo	ss	121.3	7-65	8	—	130	2	—	D	No water above 200 ft.
373	025-715	H. R. Radle	Earl Walker	1945	850	HS	Drc	6	98	40	Dmot	—	50	1945	18	—	—	—	—	D	—
374	027-716	? Swartz	—	—	675	HS	Du	36	20	—	Dfc	—	19.7	7-65	—	—	—	—	—	D	—
376	022-728	L. S. Conley	—	—	1,025	HT	Du	100±	61	—	Dor	—	53.3	8-64	—	—	45	—	55	O	—
377	022-725	J. D. Milligan	—	—	880	HS	Dr	—	214	—	Dhs	—	146.5	7-65	—	—	—	—	—	U,O	—
389	023-717	Frank Hench	Kohl Bros.	1965	655	HS	Drr	6	160	44	Swl	sh	30	1965	16	—	—	—	—	D	—
390	022-724	F. J. Dillman	do.	1964	765	V	Drc	—	134	—	Dhs	—	83	12-64	6	—	—	—	—	D,A	—
391	018-716	Maryetta Bolze	do.	1964	555	HS	Drr	6	104	35	Dhs	—	42	12-64	9	—	—	—	—	D	—
392	020-718	Tom Sweger	G. R. Blosser	1965	550	HS	Drc	6	90	46	Swl	sh	12	5-65	12	.2r	—	—	—	D	YZ: 85
396	020-718	Neal Lightner	do.	1965	595	HS	Drc	6	141	45	Swl	sh	70	9-65	10	.44	650	17	—	D	CA, YZ: 90, 138
400	020-718	Donald Bender	do.	1965	540	HS	Drc	6	70	38	Swl	sh	18	9-65	20	—	—	—	—	D	YZ: 36, 60
404	027-721	Larry Rice	John Thran	1966	650	V	Drc	6	58	—	Sto	—	29.6	4-66	10	.84	260	8	51	D	—
405	021-723	Blair Clark	G. R. Blosser	1966	600	V	Drc	6	75	21	Swu	sh	20.0	4-66	>50	>12.2	940	25	54	D,A	YZ: 45, 69
406	021-719	Jay McCoy	Joseph Cekovich	1966	560	HS	Drr	6	198	66	Sb	—	22	4-66	11	—	—	6	—	A	Little water above 150 ft.
407	024-716	H. R. Radle	do.	1965	825	HS	Drr	6	97	45	Dmot	—	5	4-66	12	—	—	—	—	D	—
408	024-716	do.	do.	1965	840	HS	Drr	6	97	40	Dms	sh	44.2	4-66	20	2.47	140	4	52	D	Fer: Most water at 60 ft.
409	018-719	D. I. Thompson	Creedon Sunday	1966	565	V	Dr	6	97	45	Sb	—	4.7	4-66	25	2.20	280	6	53	D	—
410	023-726	Mrs. Grace Palm	W. E. Hubler	1966	685	V	Drr	6	65	19	Dms	—	10.4	5-66	30	1.84	440	11	52	D	—
411	023-718	West Perry School District	Joseph Cekovich	1966	675	HS	Drr	6	495	85	Swl	sh	68.9	5-66	40	1.19	360	9	52.5	It	Fer

Table 6.—Record of wells—Continued

Well number	Location number	Owner	Driller	Date completed	Altitude above sea level (feet)	Topography	Method of construction	Diameter of casing (inches)	Total depth (feet)	Depth to bottom of casing (feet)	Aquifer: Name	Aquifer: Composition	Static water level: Depth below land surface (feet)	Static water level: Date measured	Yield (gpm)	Specific capacity (gpm per ft dd)	Field measurements of water quality: Specific conductance (micromhos at 25°C)	Field measurements of water quality: Hardness (grains per gallon)	Field measurements of water quality: Temperature (°F)	Use	Remarks
412	021–717	Donald Lyons	G. R. Blosser	1966	665	HS	Drc	6	70	54	Sto	ls	35	5–66	>12	—	—	—	—	D	Large opening at 70 ft.
413	022–719	Curtiss Binger	do.	5–66	680	D	Drc	6	140	68	Swl	sh	86.3	6–66	17	1.90	360	9	53	D	Fer. YZ: 90, 130
414	028–720	Charles Barnes	Earl Walker	—	715	HS	Drc	6	162	20	Swu	—	—	—	8	—	—	—	—	D	—
415	028–720	do.	W. E. Hubler	1964	890	HS	Drr	6	120	20	Sb	—	34.0	6–66	2	.1	105	3	54	U	—
416	025–724	W. D. Sweger	—	—	755	V	Du	36	68	—	Sto	ls	53.7	5–66	5±	—	255	7	—	D	YZ: 68
417	027–721	Fred Rice	J. M. Hubler	1966	650	HS	Drc	6	81	40	Swu	sh,ls	23.8	5–66	25	1.57	230	5	52	D	—
418	022–728	H. L. Rice	Kohl Bros.	1947	820	V	Drc	6	105	43	Swu	—	41.3	6–66	30	1.93	175	4	52.5	D	—
419	024–726	George Lombard	—	1964	1,155	HT	Dr	6	67	41	St	ss	—	—	2	—	—	—	—	D	—
420	024–726	Robert Gentzler	Joseph Cekovich	1964	1,155	HT	Drc Drr	6	122	22	St	—	60	10–64	10	—	90	2	50.5	D	—
421	022–716	Kenneth Blumenschein	do.	1966	880	HS	Drr	6	199	88	Dmot	ss	63.5	6–66	8	.25	100	1	53.5	D	Fer
422	019–727	R. R. Yohn, Jr.	G. R. Blosser	1966	690	V	Drc	6	78	37	Sb	ss	11.2	6–66	30	1.33	210	5	53	D	YZ: 40, 65
424	023–721	David Hess	Joseph Cekovich	1966	915	D	Drr	6	125	34	Dmot	ss	35.5	6–66	5	.3	230	5	—	D	YZ: 50, 110, 118
427	022–727	William Shuman	W. E. Hubler	1966	740	V	Drr	6	47	21	Dhs	ch,ls, slts,ss	15.8	6–66	>100	31.2	260	6	52	D	CA, YZ: 40
428	023–725	D. I. Hess	do.	1966	700	V	Drr	6	63	30	Dms	—	23.4	6–66	10	.52	470	10	52	D	Fer
430	018–719	James Elifritz	G. R. Blosser	1966	710	HS	Drc	6	106	88	Sb	sh,ss	24.2	7–66	10	.2r	—	—	—	D	YZ: 95
431	021–720	Tressler Memorial Church	Kohl Bros.	1966	593	D	Drr	6	223	27	Sb	sh	24.0	8–66	20	.28	—	—	—	It	YZ: 190, 213
432	020–720	Shirley Schlusser	G. R. Westbrook	1966	720	HS	Drr	6	230	38	Sr	sh	65.6	8–66	12	.2	—	—	—	D	YZ: 97, 215
433	020–720	Charles Eritts	do.	1966	735	HS	Drr	6	204	22	Sm	—	57.7	8–66	8	—	—	—	—	D	YZ: 41, 192
445	020–718	John Scheaffer	G. R. Blosser	1966	550	HS	Drc	6	98	56	Swl	ss	20	7–66	25	1.1r	—	—	—	D	YZ: 90
447	028–716	Racoon Valley Retreat	W. E. Hubler	1966	1,050	HT	Drr	6	160	—	Smo	—	100	8–66	5	—	—	—	—	D	—
450	024–720	Glen Clouse	G. R. Blosser	1966	650	V	Drc	6	52	27	Dr	sh	6	8–66	7	.3r	185	4	—	D	YZ: 46
455	019–721	J. D. Lightner	M. L. Gayman	1964	700	D	Drr	6	122	90	Swl	sh	62	6–64	20	—	50	1	—	D	YZ: 120 1.2 mg/l iron
456	020–719	H. A. Reifsnyder	Joseph Cekovich	6–66	515	V	Drr	6	123	23	Sb, Swl	—	6	6–66	1	—	370	3	53	D	0.96 mg/l iron
457	020–724	Glenn D. Gibble	J. E. Hockenberry	1966	705	V	Drc	6	70	59	Sb	sh,ss	22.9	7–66	>60	7.74	40	1	49	D	—

459	020-718	S. E. Bell	—	—	565	HS	Du	36	18	—	Swu	—	5.1	10-66	—	—	560	12	—	U	—
460	020-718	J. M. Rice	—	—	575	HS	Du	40	22	—	Swu	—	8.8	10-66	—	—	1,175	21	—	D	—
463	024-726	Harry Hartsough	J. M. Hubler	1964	1,130	HT	Drr	6	62	21	St	ss	37.8	11-66	2	—	40	1	—	D	—
466	022-719	Mildred A. Smith	Joseph Cekovich	1967	630	V	Drr	6	300	38	Swl	sh	20.5	7-67	34	.76	400	9	53	T	YZ: 24, 75, 131, 195, 215
500	027-721	L. W. Lacy	Earl Walker	1930	640	V	Drc	6	43	20	Sto	ls	7	1966	—	—	685	17	—	D	—
501	027-721	C. E. Reisinger	—	—	635	V	Du	48	20	—	Swu	—	16	7-66	—	—	—	—	—	D	—
502	027-721	M. L. Lauver	—	—	630	V	Du	48	20	—	Sto	—	—	—	—	—	450	12	—	U	—
		SNYDER COUNTY																			
Sn- 57	042-719	J. F. Henry	—	—	770	HS	Dr	6	66	30	Sw	sh,ls	15	1964	—	—	—	—	—	D	—
58	043-721	Narehood	—	—	730	HT	Dr	6	71	30	Dmh	—	33±	—	4	—	—	—	—	D	—
75	043-718	F. E. Bobb	Freed and Bell	1964	650	V	Drc	6	80	17	Dmh	sh	—	—	>20	>.7r	—	—	—	D	YZ: 30, 45, 65, 72
76	043-720	P. L. Baker	do.	1961	750	V	Drc	6	50	21	Dr	sh	1.9	9-65	8	.2r	300	7	—	D	Fer. YZ: 40
77	043-720	Harry Collabine	do.	1961	715	HT	Drc	6	110	30	Dmh	sh	40	7-61	15	.2r	245	6	—	D	YZ: 65, 90,105
78	044-721	Donald McMullen	do.	1963	775	HS	Drc	6	85	25	Dmh	sh	32	1-63	>20	1.1r	—	—	—	D	YZ: 48, 68, 77
79	044-721	Glen Berryman	do.	1960	780	HS	Drc	6	95	36	Dmh	sh	21	5-60	7	.1r	—	—	—	D	YZ: 42, 91
80	043-720	S. J. Gross	do.	1960	680	V	Drc	6	100	26	Dr	sh	29	4-60	10	.14r	—	—	—	D	YZ: 61, 89
81	042-719	Henry Erb	M. H. Romig	1960	765	HT	Drc	6	130	32	Dmt	sh	43	1-60	—	.1r	360	8	—	D	Fer. YZ: 45, 120, 125
84	044-717	Lloyd Fultz	do.	1957	715	HS	Drc	6	40	11	Df	sh	6	10-57	—	—	265	9	—	D	YZ: 30
86	042-718	C. D. Eater	do.	1959	855	HS	Drc	6	150	125	Swl	ls,sh	84	6-59	10+	.4r	160	8	—	D	YZ: 109, 115, 130
87	043-720	Paul Goss	do.	1957	695	V	Drc	6	60	10	Ds	sh	6	9-57	—	—	—	—	—	U	—
88	043-716	Glen Brower	do.	1960	685	V	Drc	6	75	44	Sto	ls	8	5-60	—	—	430	9	—	D,A	YZ: 30, 60
89	041-718	McClure Water Supply Co.	R. R. Hornberger	1964	834	HS	Drr, Drc	6	870	37	Sb	sh,ss	60±	—	33	.3r	—	—	—	P	CA, YZ: 72, 128, 245, 470, 530
90	041-718	do.	do.	1964	837	HS	Drr	6	412	37	Sb	sh	56	9-64	8	.1r	—	—	—	U	YZ: 110, 184, 245, 367
91	041-718	do.	—	1942	828	HS	Dr	—	315	—	Sb	—	+	Spring	100±	—	—	—	—	P	—
93	043-720	D. C. Boonie	Freed and Bell	1965	725	HS	Drc	6	100	17	Dmh	sh	30	6-65	15	1.4r	—	—	—	D	YZ: 65, 80, 95
96	044-718	C. F. Roger	G. R. Zechman	1954	780	HS	Drc	6	110	20	Df	—	10	5-54	12	—	—	—	—	D	YZ: 100
99	043-715	Snooks Restaurant	do.	1963	660	V	Drr	6	147	80	Sto	ls	20	9-63	1	—	—	—	—	C	YZ: 139
100	042-718	Harry Pheasant	do.	1964	790	HS	Drr	6	197	158	Swl	—	17.0	9-65	—	—	430	11	—	D	—
103	042-719	John Hassinger	J. M. Hubler	1959	760	HT	Drr	6	149	28	Dmt	sh	45	12-59	5	—	400	9	—	D	Fer
104	042-719	James Wert	do.	1959	765	HT	Drr	6	110	20	Dmt	sh	50	12-59	8	—	—	—	—	D	Fer
105	042-719	Jack Timblin	do.	1959	765	HT	Drr	6	110	20	Dmt	—	50	12-59	10	—	—	—	—	D	Fer
106	042-721	Warren Ball	do.	1962	670	V	Drc	6	44	21	Dmh	sh	5	4-62	10	—	160	3	—	D	—
107	042-719	L. H. Fisher	G. R. Zechman	1965	740	HS	Drr	6	197	155	Dms, Don	—	50	2-65	10	—	—	—	—	D	YZ: 187
108	042-718	H. W. Wagner	M. H. Romig	1962	700	V	Drc	6	55	24	Dms	sh	7	4-62	—	—	—	—	—	D	YZ: 50
109	044-719	C. D. Snook	do.	1961	735	V	Drc	6	60	42	Dmh	sh	41	10-61	15	1.5r	—	—	—	D	YZ: 50
110	044-718	H. A. Wofley	do.	1961	860	HT	Drc	6	165	21	Df	sh	51	10-61	—	—	—	—	—	D	YZ: 80, 130, 155
111	044-717	R. D. Shields	do.	1961	680	V	Drc	6	50	—	Dmh	sh	9	1-61	—	—	220	6	—	D	—
112	043-721	Clifford Wagner	do.	1962	720	HT	Drc	6	94	24	Dmh	sh	66	9-62	—	—	310	6	—	D	—
113	044-716	W. I. Renninger	do.	1961	720	HS	Drc	6	80	20	Df	sh	18	7-61	—	—	—	—	—	D	YZ: 70
117	042-720	J. R. Himes	do.	1961	720	V	Drc	6	60	22	Dmh	sh	+	8-61	—	—	275	5	—	D	H_2S, YZ: 155
120	043-720	Gerald Renninger	Freed and Bell	1964	700	V	Drc	6	100	28	Dmh	sh	41	11-64	7	.1r	260	6	—	D	YZ: 90

Table 7.—Yield and construction characteristics of drilled wells, by geologic unit

Formation	Member	Map symbol	Dominant rock type[1]	Reported yield (gpm) Number of wells	Reported yield (gpm) Median	Reported yield (gpm) Range	Well depths (feet) Number of wells	Well depths (feet) Median	Well depths (feet) Range	Casing depths (feet) Number of wells	Casing depths (feet) Median	Casing depths (feet) Range
Catskill		Dck	ss, sh	2	20	20–20	2	—	50–70	2	—	16–22
Catskill—Fort Littleton Transition Beds		Dfc	sh, ss	1	—	1	1	—	77	0	—	—
Fort Littleton		Df	ss, sh	11	9	5–20	16	75	40–350	11	20	11–80
Rush		Dr	sh	6	18	8–40	6	60	42–100	4	20	15–26
Sherman Ridge		Ds	sh, ss	17	11	1–50	21	65	30–187	18	20	10–80
Mahantango		Dmh	ss, sh	29	12	3–20	36	85	44–170	33	27	5–66
Montebello		Dmo, Dmom, Dmot	ss	24	8	2–30	27	95	35–200	19	30	20–88
Marcellus		Dm	ss, sh	4	9	5–16	4	70	48–85	4	30	24–33
	Mahanoy	Dmm	sh	29	8	1–20	29	85	34–208	27	27	9–63
	Turkey Ridge	Dmt	ss	22	12	2–30	24	85	32–149	23	28	11–52
	Shamokin	Dms	sh	13	12	5–30	17	65	36–197	17	30	13–155
Onondaga		Don	calc sh	9	8	1–25	10	90	42–125	10	40	19–85
Old Port and Oriskany—Helderberg		Do, Dho	ls, ch, ss	6	10	5–30	9	165	43–243	9	140	34–225

Oriskany	Ridgeley	Dor	ss	6	10	5–20	3	61	35–110	3	58	35–110
Oriskany and Helderberg	Shriver	Dhs	ls, ch	11	9	1–100	12	130	47–318	10	50	21–95
Keyser		Sk, Sky	ls	16	9	5–30	17	95	51–403	16	35	10–180
Tonoloway		Sto	ls	67	11	1–275	84	95	40–504	72	33	8–102
Wills Creek		Sw	sh	18	14	1–45	21	110	27–303	20	28	12–78
	Upper	Swu	sh, ls	42	15	5–100	52	85	20–454	46	40	14–82
	Lower	Swl	sh	51	15	5–160	57	85	26–495	54	42	12–158
Bloomsburg		Sb	sh, ss	55	13	1–100	60	100	50–870	55	35	6–108
Mifflintown		Sm	ls, sh	19	11	1–15	7	70	46–350	6	24	12–46
	McKenzie and Rochester	Smm	ls, sh	10	10	1–30	14	75	55–310	11	26	20–32
	Keefer	Smk	ss	3	6	1–12	6	68	46–130	2	—	7–30
Rose Hill		Sr	sh	24	10	1–35	26	115	50–370	25	36	5–67
Tuscarora		St	ss	4	6	1–10	5	67	50–250	3	35	22–42
Juniata		Oj	ss, sh	0	—	—	0	—	—	0	—	—
Bald Eagle		Ob	ss, cg	0	—	—	0	—	—	0	—	—
Reedsville and Martinsburg		Or, Om	sh	35	13	5–50	34	85	38–250	30	37	15–81

[1] Calcareous shale, calc, sh; Chert, ch; conglomerate, cg; limestone, ls; shale, sh; sandstone, ss.

bedrock which wells must penetrate in order to obtain a yield of about 10 gpm. Most of the wells in this group are between 50 and 170 feet deep, and the median depth is 88 feet. Only 6 percent are less than 50 feet deep, and only 10 percent are more than 170 feet deep. The deepest domestic and farm wells have been drilled on hillsides and ridges underlain by the Oriskany, Helderberg, and Old Port Formations. More than half of the wells drilled into these rock units in valleys, on the other hand, are generally no deeper than valley wells in most other units.

The deepest well (Ju-105) in the study area is a gas-test well that was drilled to a depth of 10,036 feet (and later plugged) on Shade Mountain, about 3½ miles north of McAlisterville. The well started in the Reedsville Formation and ended in carbonate rocks of Early Ordovician age.

Casing

Casing is installed in wells in the study area mainly to prevent the mantle of soil and saprolite from collapsing into the borehole. In the majority of wells, steel casing is seated 3 or 4 feet into the solid bedrock; the remainder of the hole is then completed at a slightly smaller diameter, without additional casing. Casing has been extended more than a few feet below the bedrock surface in some wells, either because of contract specifications, or because a zone of unconsolidated or strongly fractured material, which would not maintain an open borehole, was encountered at greater depths.

Most of the wells in the study area contain 20 to 50 feet of casing, but casing depths range from 5 feet to 225 feet. The median and range of casing depths for indvidual formations and members are given in Table 7. The amount of casing required differs according to topography and the rock type. Wells drilled on hillsides normally require more casing than those drilled in valleys, and wells drilled in limestones and calcareous shales generally require more casing than those drilled in sandstone and noncalcareous shales.

The median depth of well casing in 283 wells drilled on hillsides is 37 feet, and the median depth of casing 217 wells drilled in valleys is 23 feet. Moreover, about 30 percent of the wells on hillsides have more than 50 feet of casing, whereas only 8 percent of the wells in valleys have more than this amount. The greater depth of casing in wells on hillsides is a reflection of the greater depth of weathering beneath hillsides.

Wells drilled in noncalcareous shales and sandstones generally contain less than 50 feet of casing, regardless of topographic position. Most of the wells containing more than 50 feet of casing are those that have been drilled into hillsides underlain by calcareous-rock units.

The weathered zone is especially deep beneath hillsides underlain by the Keyser, Helderberg, Oriskany, and Old Port Formations. More than one-

third of the wells drilled in such localities have required between 100 and 225 feet of casing. The median casing depth for hillside wells in these calcareous units is 58 feet.

The annular opening between the outside of the casing and the borehole wall of most wells in the study area has been allowed to fill with well cuttings during the drilling operation. The general effectiveness of this type of casing seal in preventing the direct entry of shallow ground water (which may be polloutcd by septic tank effluent) into the well is not known. In a few instances, water levels in nearby hand-dug wells are higher than those in the drilled wells, indicating that the seal probably is effective. However, a few wells were examined in which water was found to be entering at or near the bottom of the casing, indicating that the casing seals were defective. Inasmuch as the annular opening is narrow (about 1-inch wide in most 6-inch wells), bridging of drill cuttings probably occurs around some casings. Bridging of material at depths of a few feet below land surface may leave much of the annular opening unsealed and, thus, permit relatively direct and rapid movement of shallow ground water into the wells. A few wells have been sealed with cement grout. The use of cement grount generally provides a reliable and effective seal.

Yields

The yields of most wells listed in Table 6 were determined by the driller, either on the basis of a short-term bailing test or by measuring the discharge from an air-rotary drill. Few such tests exceeded one hour in duration, although some yielding zones that were penetrated at shallow depths by air-rotary drills may have been pumped for several hours while the well was being drilled to final depth. The drawdowns of water levels during the yield tests were reported for only a few of the wells that were tested by the bailing method. The reported drawdowns are only rough estimates of the true drawdowns. Specific capacities have been computed for several wells by using the drillers reported yield and drawdown data (Table 6). These specific capacities are considered to be only order-of-magnitude and were not used in relating well yield to the various parameters discussed in subsequent sections.

The yields reported for 534 wells range from less than 1 gpm to 275 gpm. Half of the wells reportedly yield 12 gpm or less, and fewer than 5 percent are reported to yield more than 50 gpm. The percentage distribution of reported well yields is shown in Figure 9. The median and range of reported yields for individual formations and members are given in Table 7. The median yields of all rocks units range from 6 to 20 gpm.

Although the reported yield data are imprecise and do not reflect the maximum potential of wells in the study area, they do suggest that the potential is low and that the chances of obtaining a relatively high yield

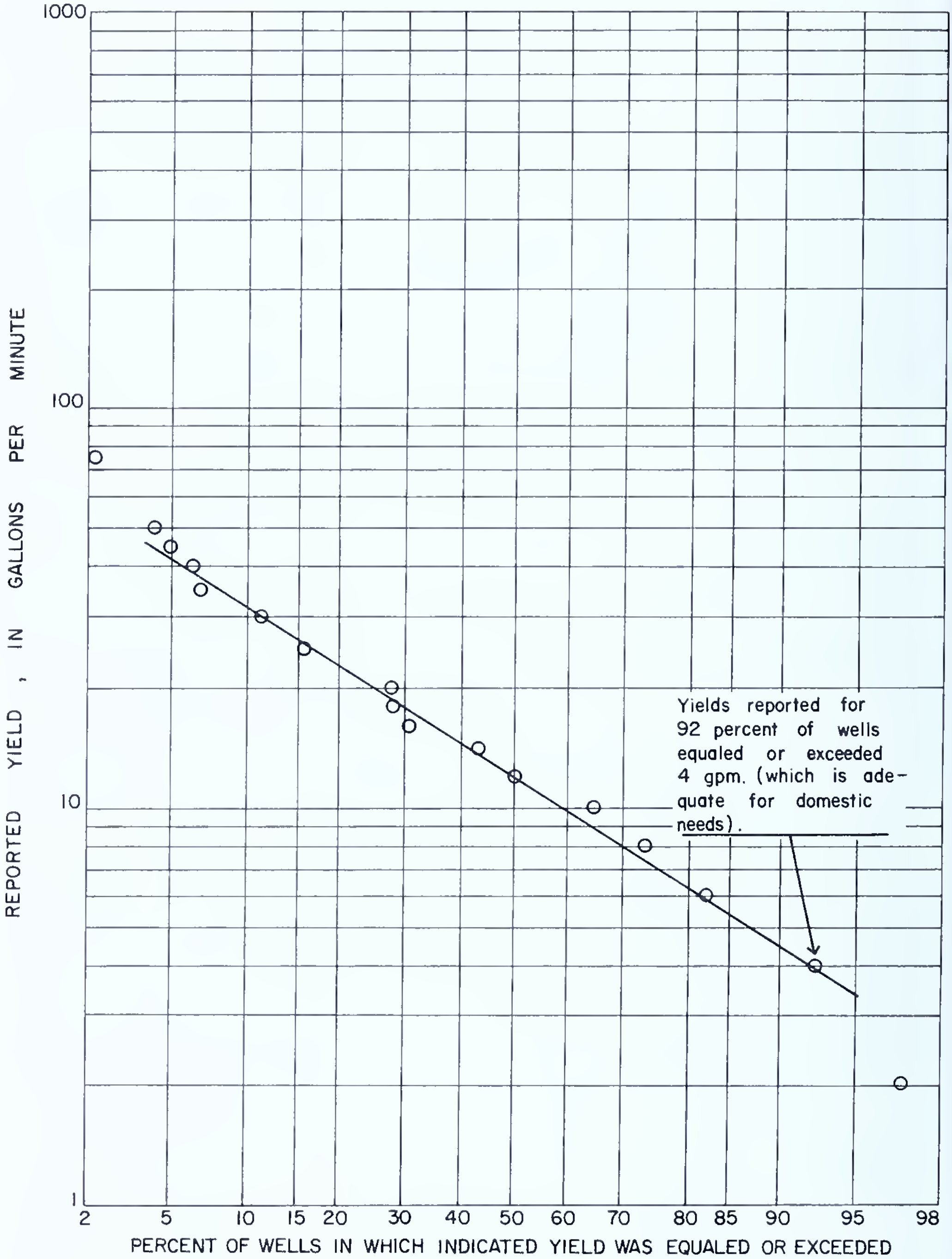


Figure 9. Frequency graph of yields reported for 534 wells.

(100 gpm or more) from a well drilled at a randomly selected site in any formation are poor.

In the following sections, yield data are evaluated to determine the effects of such factors as rock type, topographic position, and well depth on well yields. The yield data used include only those obtained from depth on well yields. The yield data used include only those obtained from controlled pumping tests, from which the specific capacities could be determined.

Specific Capacity Data

The yields of wells can be given more comparability through the use of specific capacities, which are commonly expressed as the yield in gallons per minute per foot of drawdown (gpm per ft) for a stated period and rate of pumping. The period of pumping is stated because water levels usually continue to decline as the test lengthens, causing specific capacity values to decline accordingly. The rate of pumping is stated because specific capacities measured at different rates of pumping over the same interval of time may differ significantly as a result of (1) a decrease in well efficiency at higher pumping rates, or (2) the pumping level being lowered below yielding zones.

Most of the specific capacity data used for this report were computed from tests of about the same duration; hence, variations in specific capacity due to differing pumping times are minimal. Furthermore, most of the pumping tests were made at low rates of discharge, such as are produced by the pumps in most domestic wells; thus, drawdown effects related to decreases in well efficiency and the lowering of pumping levels below yielding zones should also be minimal. The specific capacities obtained for most of the wells, therefore, should be the highest values obtainable from them for the stated duration of testing.

Table 8 lists specific capacities of 79 wells. All but eight of the values were determined from short-term pumping tests made by the author, using either the installed pump or a portable submersible pump. Most of the tests were made for a period of 1 hour and at pumping rates that ranged from 3 to 25 gpm. A few tests made with the owner's pump were pumped for less than 1 hour when drawdown rates were excessive. Where possible, specific capacities of these wells were estimated for a 1-hour pumping period by extrapolating the drawdown. The eight values which were determined from tests other than those made by the author represent the only specific-capacity data obtained from other wells for which controlled pumping-test data were available.

The specific capacities range from less than 0.1 gpm per ft to 63 gpm per ft and the median is 0.55 gpm per ft. About 12 percent of the wells have specific capacities of 0.1 or less and 10 percent have specfic capacities of 3.0 or more.

For most of the 1-hour pumping tests, drawdown rates remained relatively high at the end of the test. If the wells had been pumped for periods of 24 hours or more, the specific capacities of most of these wells would have been considerably smaller—perhaps only half as much as was measured. Even so, the specific capacities obtained are generally low, indicating that the permeability of the first 100 feet or so of the bedrock—the average depth of the wells tested—is also low.

No consistent relation exists between these short-term specific capacities and the potential yield of wells, but the highest yields generally are obtain-

Table 8.—Summary of specific-capacity data used to evaluate the affects of lithology, topography, and depth on well yield

Well number	Formation	Member	Topography	Depth of well (feet)	Diameter of casing (inches)	Depth of casing (feet)	Depth to static water level (feet)	Drawdown (feet)	Rate of pumping (gpm)	Specific capacity (gpm per ft)	Length of test (minutes)	Date of test
Cumberland County												
Cu-154	Martinsburg	—	Valley	70	6	70	7.8	10.2	3.9	0.36	60	Mar. 1966
155	do.	—	Hillside	166	6	—	19.0	16.2	10.2	.63	60	July 1965
156	do.	—	Valley	107	6	20	13.4	5.1	6.2	1.21	60	May 1966
157	do.	—	Hillside	71	6	16	18.1	33.1	6.2	.19	60	July 1965
170	do.	—	do.	60	6	—	3.8	2.8	8.5	3.0	60	May 1966
178	do.	—	Valley	65	6	20	1.8	14.8	5.0	< .3	6	May 1966
Juniata County												
Ju- 17	Wills Creek	—	Valley	263	8	57	29	78	85	[a]1.1	2,880	—
18	do.	—	do.	454	8	18	18.2	64.0	8.8	.14	60	Oct. 1964
71	Mifflintown and Rose Hill	Keefer	Hillside	472	8	—	69.5	72.0	8.2	.11	60	—
72	Wills Creek	Upper	Valley	210	8	17	11	64	80	[a]1.25	1,920	—
73	Tonoloway	—	do.	504	8	—	15	160	75	[a].5	—	1939
75	Wills Creek	Lower	Hillside	92	6	60	6.0	5.8	22.2	3.86	180	Dec. 1964
86	Marcellus	Turkey Ridge	Valley	110	6	30	21.0	22.2	5.3	.23	60	Sept. 1964
96	Bloomsburg	—	Hillside	248	6	—	31.3	24.9	17.2	0.69	60	June 1965
97	do.	—	do.	225	6	—	30.2	15.3	8.7	.57	60	June 1965
160	Mifflintown	—	Valley	350	8	25	2.3	35.8	10.9	[b].1	24	Aug. 1965
189	do.	McKenzie-Rochester	Hillside	57	6	20	14.0	19.0	6.8	.34	60	Aug. 1965
206	Keyser	—	Valley	59	6	26	17.7	7.0	3.0	[b].4	6	Aug. 1965

21[illegible]	Rose Hill	—	do.	82	6	—	19.0	12.0	3.6	.3	18	Aug. 1966
224	Wills Creek	Upper	do.	73	6	—	25.4	.9	5.7	6.1	60	July 1965
249	Mifflintown and Rose Hill	Keefer	Hillside	268	6	30	—	77.2	11.6	<[b].1	12	—
255	do.	—	do.	75	6	17	12	48.0	5.	<[b].1	30	Sept. 1965
261	Keyser	—	do.	223	6	40	91.8	41.3	8.4	<[b].1	30	Aug. 1965
268	Wills Creek	Lower	Valley	61	6	—	12.0	8.8	8.0	.91	60	Sept. 1965
269	Rose Hill	—	do.	90	6	32	31.3	13.3	4.0	.30	60	Sept. 1965
280	Wills Creek	—	do.	72	6	62	3.1	7.1	12.7	1.80	60	May 1955
282	Tonoloway	—	Hillside	98	6	—	46.6	23.4	6.1	<[b].26	24	May 1966
283	Tonoloway	—	Valley	375	6	26	8.7	1.6	102	63	60	June 1966
284	Mifflintown	Keefer	do.	92	6	21	16.9	53.1	6.2	<[b].1	12	Sept. 1966
289	do.	McKenzie-Rochester	Hillside	53	6	10	4.7	9.8	4.2	.40	60	Sept. 1966
295	Marcellus	Shamokin	Draw	82	6	27	22.5	5.4	4.7	.88	60	Sept. 1966
					Mifflin County							
Mf-134	Mahantango	—	Valley	90	6	33	32.0	10.8	11.2	1.04	60	Sept. 1965
152	Reedsville	—	do.	250	8	69	25.6	88.8	[a]46	.52	1,440	Dec. 1965
180	Montebello	—	Hillside	100	6	54	30.9	7.2	7.3	1.0	60	May 1965
200	Old Port	—	do.	243	6	207	122	9.5	6	<[b].3	8	Dec. 1965
214	Marcellus	Mahanoy	Valley	110	6	39	5.5	7.4	6.6	.90	60	Mar. 1966
219	Old Port	Ridgeley	Hillside	58	6	58	38.4	9.6	5.7	.59	60	Mar. 1966
229	Tonoloway	—	Valley	61	6	—	5.4	5.4	14	2.6	60	Apr. 1966
					Perry County							
Pe- 65	Wills Creek	Lower	Valley	247	6	18	15	4	160	[a]40	—	—
72	Rose Hill	—	Hillside	178	6	36	60	30	20	[a].67	—	Aug. 1959
74	do.	—	Valley	169	6	5	20	100	36	[a].36	120	—
83	Tonoloway	—	Hillside	92	6	40	13.8	27.2	4.8	.18	60	July 1965

Table 8.—Summary of specific-capacity data used to evaluate the affects of lithology, topography, and depth on well yield—Continued

Well number	Formation	Member	Topography	Depth of well (feet)	Diameter of casing (inches)	Depth of casing (feet)	Depth to static water level (feet)	Drawdown (feet)	Rate of pumping (gpm)	Specific capacity (gpm per ft)	Length of test (minutes)	Date of test
113	Wills Creek	Lower	Valley	80	6	35	15.0	18	7.4	.41	60	July 1966
116	Bloomsburg	—	Hillside	95	6	39	22.3	13.8	5	[b].33	30	July 1965
146	Tonoloway	—	Valley	75	6	50	16.1	3.5	7.7	2.15	60	June 1965
202	Wills Creek	Lower	do.	112	6	35	20.4	15.9	6.7	.42	60	Sept. 1966
205	do.	do.	Hillside	85	6	37	32.2	9.5	7.5	.79	60	July 1965
211	Montebello	—	do.	70	6	40	24.4	18.1	20.2	.84	60	June 1965
219	Bloomsburg	—	Valley	55	6	23	8.2	7.2	4.9	.68	60	July 1965
222	Wills Creek	Upper	do.	124	4	21	14.80	13.6	9.3	.68	60	July 1965
230	Tonoloway	—	do.	170	6	20	10.1	17.9	6.1	.34	60	July 1965
235	Bloomsburg	—	Hilltop	165	6	20	45.6	32.7	2.8	<[b].1	20	Aug. 1965
238	Marcellus	Shamokin	Valley	46	6	17	3.6	19.1	10.7	.56	60	Aug. 1965
241	Helderberg	—	Hillside	150	6	50	114.7	6.7	3	<[b].1	8	Aug. 1965
244	Rush	—	Valley	47	6	—	6.5	14.9	8.3	.55	60	July 1965
255	Marcellus	Turkey Ridge	Draw	123	6	30	30.8	29.4	9.1	.31	60	July 1965
307	Rose Hill	—	Hillside	139	6	68	26.0	38.6	5.9	.15	30	Aug. 1965
338	Sherman Ridge	—	Valley	81	6	—	14.9	53.4	4.1	<[b].1	20	July 1956
348	Wills Creek	Upper	Hillside	212	8	31	35	116.7	42.4	[a].36	360	July 1952
396	do.	Lower	do.	141	6	45	70	10.7	4.8	.44	60	Sept. 1965
404	Tonoloway	—	Valley	58	6	—	29.6	14.2	11.9	.84	60	April 1966
405	Wills Creek	Upper	do.	75	6	21	20.0	.7	8.0	12.2	60	April 1966
408	Marcellus	Shamokin	Hillside	97	6	40	44.2	2.1	5.1	2.47	60	April 1966
409	Bloomsburg	—	Valley	97	6	45	4.7	11.4	25.2	2.20	60	April 1966
410	Marcellus	Shamokin	do.	65	6	19	10.4	12.8	23.7	1.84	60	May 1966

411	Wills Creek	Lower	Hillside	495	6	85	68.9	18.2	21.7	1.19	60	May 1966
413	do.	do.	Draw	140	6	68	86.3	4.4	8.4	1.90	60	June 1966
415	Bloomsburg	—	Hillside	120	6	20	34.0	31.7	4.5	<[b].1	24	June 1966
417	Wills Creek	Upper	do.	81	6	40	23.8	7.5	11.7	1.57	60	May 1966
418	Wills Creek	Upper	Valley	105	6	43	41.3	13.0	5.8	1.93	60	June 1966
421	Montebello	—	Hillside	199	6	88	63.5	31.8	8.0	.25	60	June 1966
422	Bloomsburg	—	Valley	78	6	37	11.2	18.5	24.5	1.33	60	June 1966
424	Montebello	—	Draw	125	6	34	35.5	37	20	<[b].3	6	June 1966
427	Helderberg	—	Valley	47	6	21	15.8	.8	25.3	31.2	60	June 1966
428	Marcellus	Shamokin	do.	63	6	30	23.4	14.3	7.4	.52	60	June 1966
431	Bloomsburg	—	Draw	223	6	27	24.0	32.5	9.0	.28	60	Aug. 1966
432	Rose Hill	—	Hillside	230	6	38	65.6	29.9	6.0	.20	60	Aug. 1966
457	Bloomsburg	—	Valley	70	6	59	22.9	1.6	12.3	7.74	60	July 1966
466	Wills Creek	Lower	Valley	300	6	38	20.5	28.4	21.7	.76	60	June 1967

[a] Calculated from data reported for controlled pumping test.

[b] Determined by extrapolating drawdown to one hour.

able from those wells having the highest specific capacities. The number, depth, and relative contribution of yielding zones generally are not the same for any two non-adjacent wells. Accordingly, wells of equal depth, in which the depth to water is the same, may have equal short-term specific capacities but different yields at maximum available drawdowns.

Because of the areal variations in the permeability of fractured-rock aquifers, specific-capacity data tend to be erratic also. Frequency graphs are used to facilitate comparison of the inconsistent specific-capacity data obtained for wells in different rock types, of different depths, and in different topographic settings. Plots of specific-capacity data on frequency graphs illustrate differences in aquifer characteristics that may not be readily apparent from an inspection of the tabulated data. The slope of lines fitted to data plots for wells of equal depth, in a single rock unit indicate the degree of variability in bedrock permeability. The steeper the slope, the greater the variability in permeability. The relative positions of two or more frequency curves may also provide a measure of the relative permeabilities of one or more rock types. The higher the position of the curve, the higher will be the average permeability of the rock type being considered.

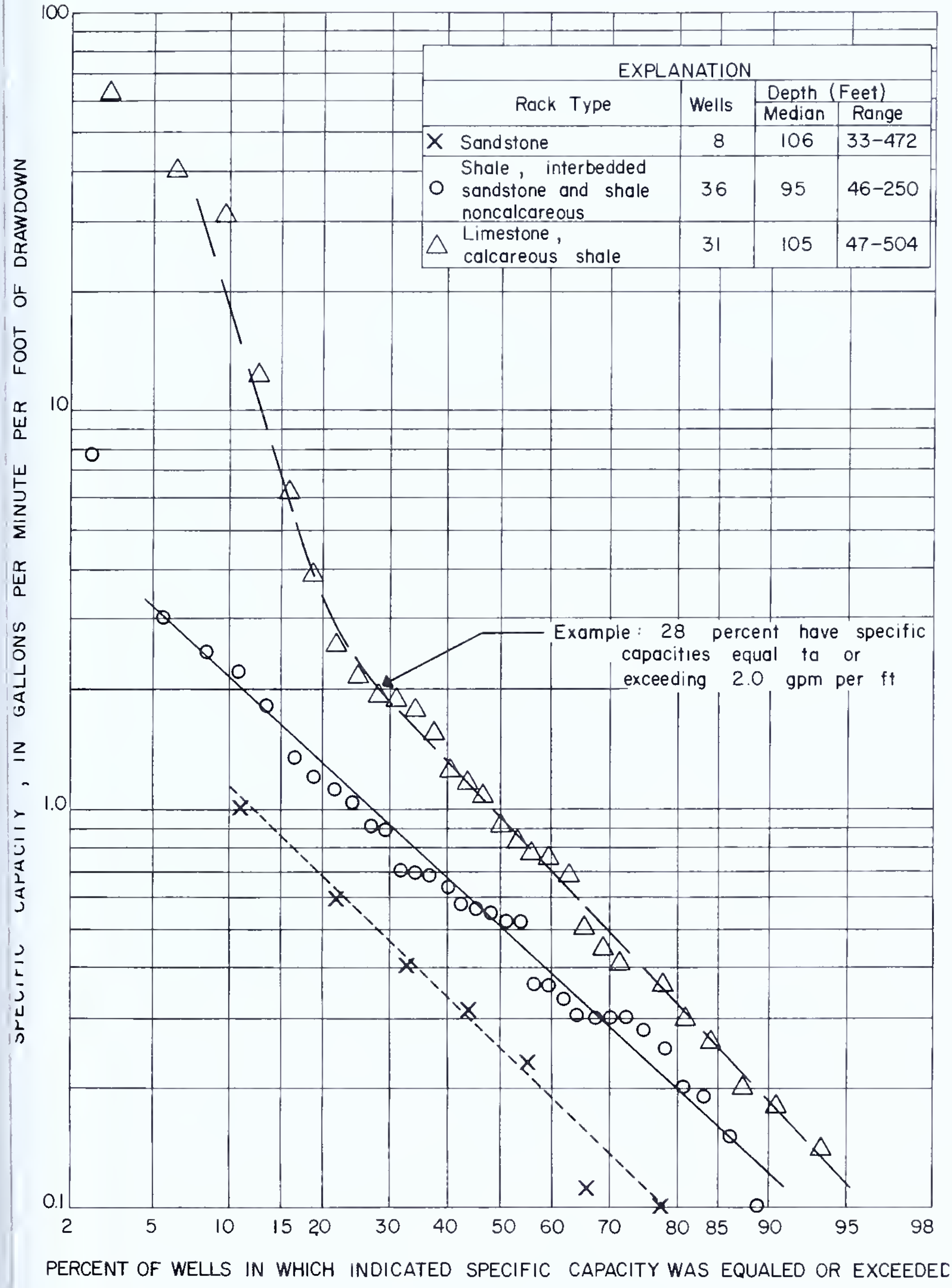
Relation of Well Yield to Rock Type

Not enough specific-capacity data were available to permit statistical comparison of the water-yielding properties of wells in each rock type. Therefore, the data were combined into three groups consisting of data from wells in rock units composed dominantly of (1) limestone and calcareous shale; (2) non-calcareous shale (or interbedded non-calcareous shale and sandstone); and (3) sandstone.

Calcareous shale is represented solely by data from wells in the Wills Creek Formation. Separate frequency curves were prepared for wells in units composed dominantly of shale and for wells in units composed dominantly of interbedded shale and sandstone. However, the curves were so similar that the data were combined to give a single curve.

The frequency curves shown in Figure 10 indicate that the chances of obtaining a given specific capacity from a well drilled at a site selected at random are greatest when the well is in limestone and calcareous shale units and least when it is in sandstone units. For example, the curves indicate that a specific capacity of 1.0 gpm per ft is obtainable from about 48 percent of the wells drilled in calcareous rock units, from about 27 percent of the wells drilled in non-calcareous shale and interbedded sandstone and shale units, and from about 12 percent of the wells drilled in sandstone units.

The steep slopes of the frequency curves is an indication of the relatively wide range in permeability that exists in all rock types. The steep break in slope of the curve for specific capacities of wells in calcareous rock units is caused by a few wells in valleys that tap large solution openings.



igure 10. Specific-capacity frequency graph for wells in several rock types.

Relation of Well Yield To Topography

Studies of several areas that are underlain by consolidated bedrock have shown that the average yield of wells in valleys is higher than that of wells at topographically higher positions (LeGrand, 1949; Mundorff, 1948; Dingman and Meyer, 1954; Poth, 1968). This relation indicates, of course, that the average permeability of the bedrock beneath valleys is higher than that beneath hillsides and hilltops. Where permeability differences related to topographic position occur in areas underlain by the same or similar rock types, the differences may be related to differences in the volume of water that passes through the rocks. As ground water moves from drainage divides toward streams, the volume of water increases because of the addition of recharge from precipitation; thus, a progressively larger volume of water must pass through the same—or even smaller—volume of rock as the ground water approaches the stream. The flow of large volumes of water through the rock underlying valleys probably causes greater solution and removal of rock material from fracture surfaces in the valleys than in the highlands, thereby increasing the permeability of the bedrock in the valleys.

An examination of the specific-capacity data collected from wells in similar rock types shows that the specific capacities of wells in valleys and draws are generally higher than those of wells on hillsides and hilltops. Moreover, unusually high specific capacities were obtained only in valley wells. The relation between the topographic location and yield per foot of drawdown of wells is shown in Figure 11. Data from wells in sandstone were too few to be considered separately and, therefore, were combined with data from wells in interbedded non-calcareous shale and sandstone.

The graph shows, for example, that about one out of two (55 percent) wells in valleys and draws underlain by calcareous shale and limestones have a specific capacity of 1.0 gpm per ft, or more; whereas, only one out of three (33 percent) wells on hillsides and hilltops underlain by these rock types have a specific capacity of 1.0 or more. Extending the comparison to hillside and hilltop wells in non-calcareous shales and sandstone, it can be seen that only one out of six (16 percent) wells in this group have a specific capacity of 1.0 or more.

The comparatively steep slopes of the averaged frequency distributions indicate that wide variations in specific capacities of wells can be expected, regardless of the topographic position of the well.

Valleys are favorable areas for drilling wells because of the high average bedrock permeabilities, and because of the potential for obtaining induced recharge from streams. If the hydraulic connection between a well and a stream is good, the recharge induced will reduce drawdown due to pumping and, thus, help sustain the yield of the well.

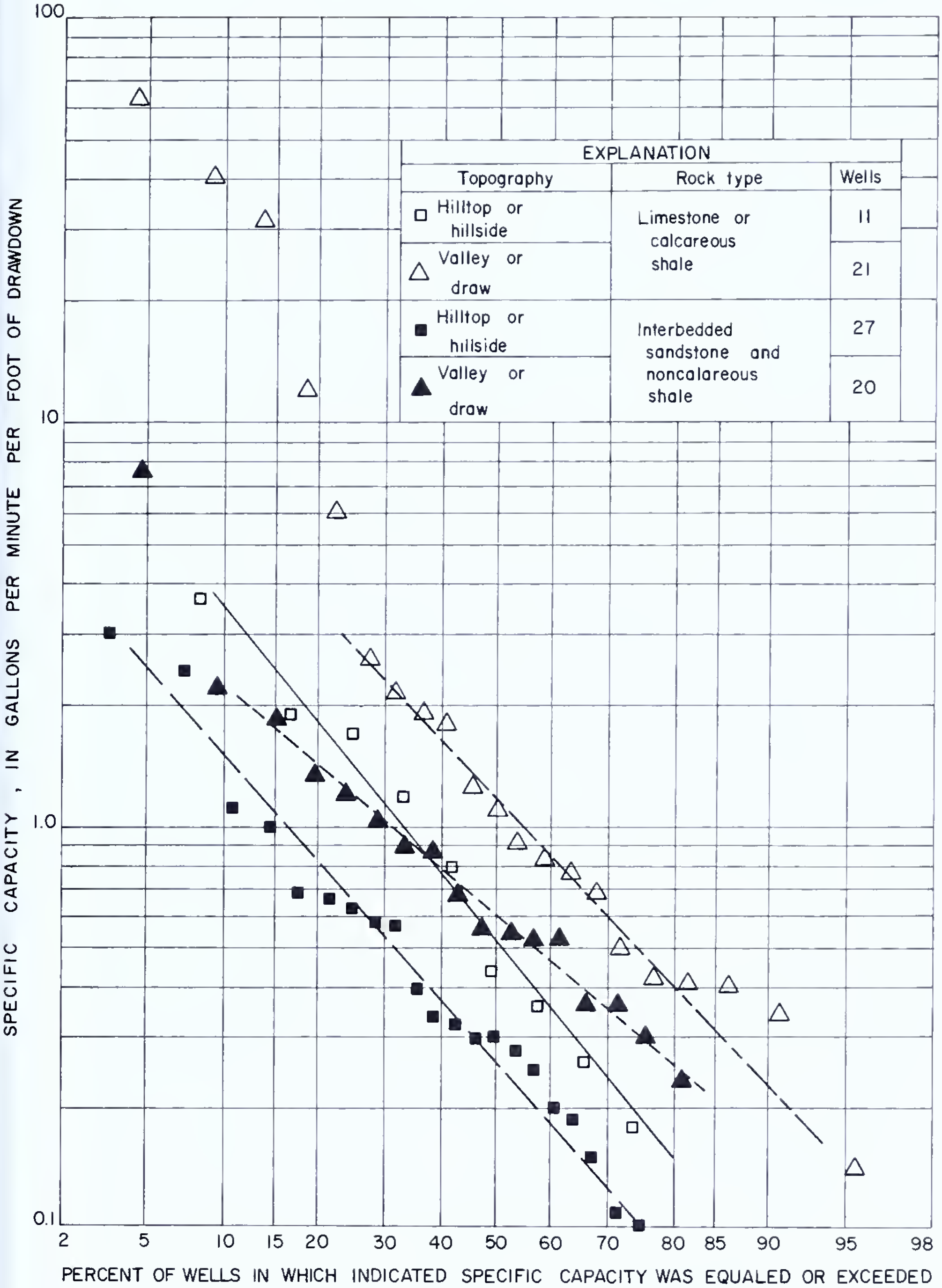


Figure 11. Specific-capacity frequency graph for wells at different topographic locations in calcareous and non-calcareous rocks.

Relation of Well Yield to Depth

Fracture permeability is unevenly distributed, both vertically and horizontally, in most fractured-rock aquifers. As a result, closely-spaced wells of equal depth may have very different yields. Fracture permeability also decreases at depth, as the size and number of openings decrease, and below some depth, the bedrock will yield little or no additional water to wells.

The depth at which bedrock in the Loysville and Mifflintown quadrangles will yield little or no water to wells is not known. However, data from a few wells suggest that most of the yield obtainable from wells may be expected to come from depths less than 200 feet.

Measurements of the drilling discharge made at different depths during construction of well Ju-283 indicate that 90 percent of the yield enters above a depth of 200 feet. This well, which will yield in excess of 200 gpm, is 375 feet deep and penetrates limestone of the Tonoloway Formation. Measurements of the borehole flow, made over different intervals of depth, in wells Mf-152, Pe-411, and Pe-466, which are 250, 495, and 300 feet deep, respectively, indicate that most of the water enters these wells at depths of less than 200 feet. In well Mf-152, which penetrates non-calcareous shale of the Reedsville Formation, borehole-flow measurements indicate that little or no water enters below a depth of about 150 feet. In well Pe-411, which penetrates calcareous shale of the Wills Creek Formation, 90 percent of the yield enters above a depth of 200 feet; little or no water enters in the depth interval between 300 and 495 feet. In test well Pe-466, about 75 percent of the yield enters above a depth of 200 feet. Flow measurements made in well Pe-466 under non-pumping conditions showed that water entered from several zones below a depth of 75 feet, moved downward, and left the well at a depth of about 265 feet. Maximum outflow at the thieving zone amounts to about 1 gpm.

Borehole-flow measurements were made by the brine tracing method described by Patten and Bennet (1962, p. C2). The method involves the introduction of brine slugs into a well at one or more depths and tracing their rate and direction of movement by means of a fluid conductivity instrument suspended in the well on a depth-calibrated cable.

Examination of reported-yield data available for 53 wells more than 200 feet deep shows that 26 (or about half) yield 10 gpm or less, and that only 6 yield more than 50 gpm. One of these six wells is test well Ju-283. Half of the wells penetrate limestone or calcareous shale, and although the yields of these wells are generally somewhat greater than those of wells in non-calcareous shale and sandstone units, one-third of them yield 10 gpm or less. The failure of several deep wells to obtain yields of more than a few gallons per minute indicates that there are places where the rock is relatively impermeable from the surface downward.

The deepest water well in the study area is Sn-89, which is 870 feet deep and reportedly yields about 30 gpm. Well Sn-90, which is approximately 50 feet from well Sn-89, is 412 feet deep and reportedly yields 10 gpm. Well Sn-91, which is about 150 feet from Sn-89, is reported to yield 100 gpm and is 315 feet deep. All three wells penetrate shale and sandstone of the Bloomsburg Formation near the community of McClure. Wells Sn-89 and Sn-91 supply water to this community; Sn-90 is not used.

The deepest well in the project area is a now-sealed gas test well (Ju-105) that was drilled to a depth of 10,036 feet on Shale Mountain, in the Mifflintown quadrangle. The well starts in the Late Ordovician shale of the Reedsville Formation and ends in carbonate rocks of Middle to Early Ordovician age. Information obtained from Donald Robertson of Shell Oil Company (1967, oral commun.) indicates that the well was cased to a depth of 1,215 feet to prevent the inflow of about 35 gpm of fresh water. The depths at which water entered the well are not known. Little or no fresh water entered the open borehole below the casing. Salt water was encountered at a depth of 9,040 feet.

Frequency curves of specfic-capacity data for wells of three depth ranges is shown in Figure 12. The relative positions of the curves indicate that the specific capacities of the wells sampled are generally higher for wells less than 100 feet deep than they are for deeper wells. The data are obviously biased, because in any large group of randomly located wells drilled to random depths selected in advance of drilling, the deep wells should have specific capacities at least equal to those of the shallow wells. Wells samples for this study may be considered to be randomly located, but many of them were drilled only as deep as was necessary to obtain a yield adequate for domestic or farm needs. Hence, the low specific capacities of several of the deeper wells represent values for wells that were drilled to greater than average depths in an attempt to obtain yields approximating those that were obtained at shallower depths in most wells. That is to say, the low specific capacities in many of the deep wells are representative of rocks having lower-than-average permeability.

The data collected for this study suggest that the chances of obtaining substantial yields from wells are greatest at depths of less than 200 feet. Some water is likely to be obtained at depths of 400 feet or more, but the percentage of wells that will yield significant quantities of water from such depths is likely to be small. When a well that has been drilled to a depth of 200 feet has yielded no more than a few gallons per minute, it generally is advisable to drill at a new site rather than drill deeper. The new site preferably should be where the new well will penetrate a different sequence of beds. Different beds generally will be penetrated if the new well is drilled northwest or southeast of the unsuccessful well. That is, across the general trend of the bedding. The distance that it would be necessary to move, in

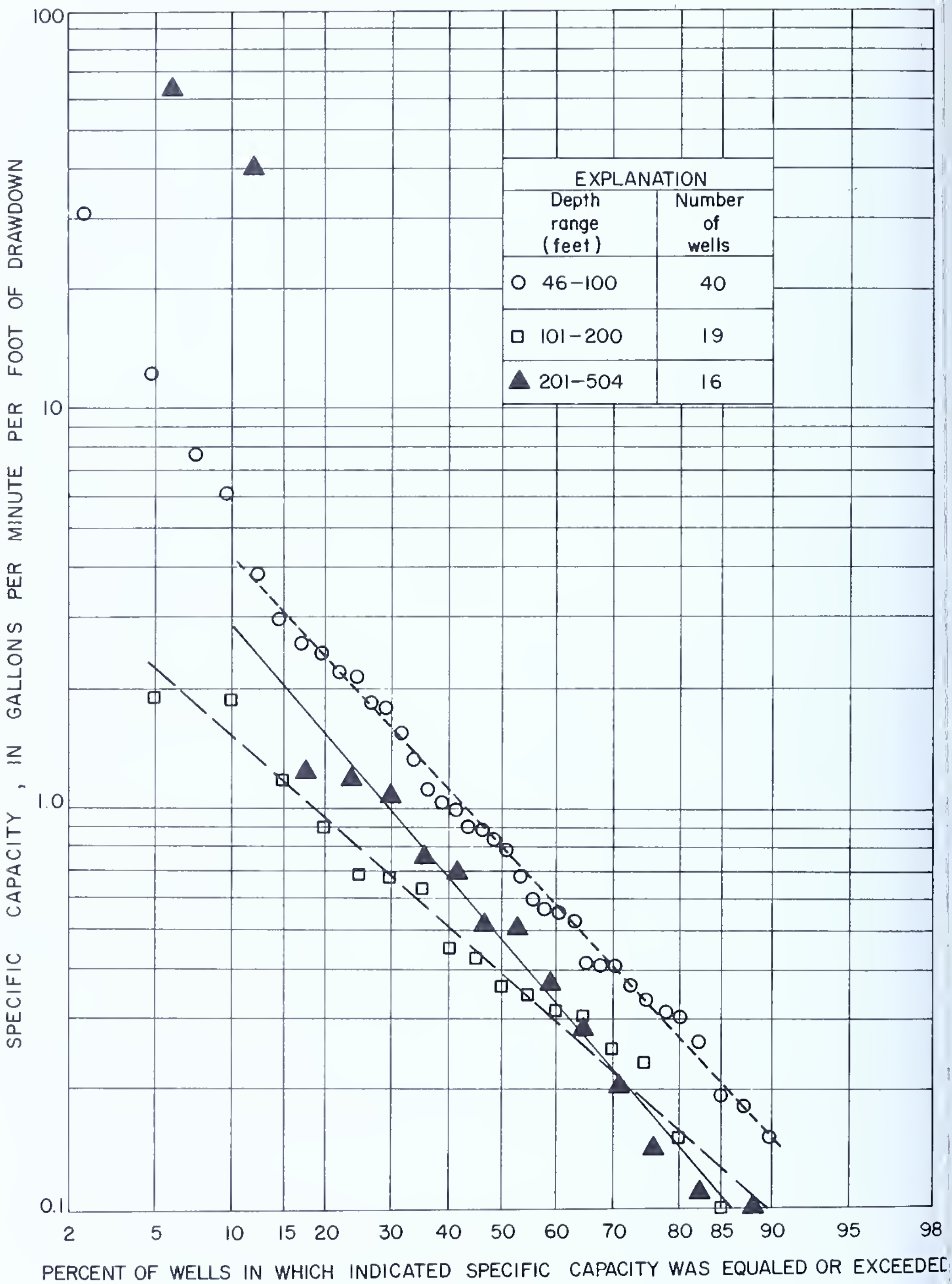


Figure 12. Specific-capacity frequency graph for wells in three depth classes.

order to penetrate an entirely new sequence of beds, can be determined from the dip and strike symbols on the maps accompanying this report. (Plates 1 and 2)

WATER-YIELDING POTENTIAL OF ROCK UNITS

Rock units shown on the maps of the Loysville and Mifflintown quadrangles (Plates 1 and 2) have been assigned to one of three general categories (good, fair, or poor) depending on their relative potential for yielding water to wells. Assignments were based in part on specific-capacity and reported well-yield data and in part on topographic and lithologic considerations. Specific-capacity and yield data were sparse for some units so that their assignments to one of the three categories was based primarily on their dominant rock type and topographic position. Formations for which few data were obtainable include the Bald Eagle, Juniata, and Tuscarora Formations—which underlie the crests and steepest slopes of the principal mountains—and the Rush, Fort Littleton, and Catskill Formations, which underlie sparsely inhabited areas.

Yields adequate for domestic needs (3 gpm or more) can be obtained from all formations, generally from wells between 50 and 150 feet deep. Yields of 3 to 5 gpm are obtainable at these depths even on crests and steep slopes of ridges, although somewhat deeper wells may be required where the bedrock is composed of calcareous rock units.

Rock units rated as having good potential for yielding water to wells comprise the dominantly calcareous units of Late Silurian and Early Devonian age. Included in this group are the Wills Creek, Tonoloway, Keyser, Oriskany, Helderberg, Old Port, and Onondaga Formations. Maximum sustained yields obtainable from these units probably are on the order of 300 to 400 gpm, although a few wells, such as test well Ju-283, that tap solution openings in limestone may be capable of sustaining greater yields. Estimates of potential yield based on frequency graphs of specific capacity data indicate that about 25 percent of the wells drilled to depths of at least 200 feet in valleys in these units may be expected to sustain yields of 86 gpm, or more.

The Wills Creek and Tonoloway Formations are potentially the most important aquifers in the study area. These units underlie considerably more valley area than do other calcareous rock units. The Keyser, Oriskany, Helderberg, and Old Port Formations underlie minor ridges and relatively steep slopes throughout much of the study area, which reduces their potential. Even so, the frequency graphs in Figure 11 indicate that the probability of obtaining a given specific capacity is about the same for wells on hillsides in calcareous rock units as for valley wells in non-calcareous rock units.

Rock units rated as having fair yielding potential to wells include most of the units composed dominantly of non-calcareous shales and interbedded sandstones and shales that do not underlie steep slopes and crests of mountains. Included in this group are the Catskill, Fort Littleton, Rush, and Sherman Ridge Formations, the Mahanoy and Shamokin members of the Marcellus Formation, and the Bloomsburg, Reedsville, and Martinsburg

Formations. Maximum sustained yields obtainable from wells in valleys in these units are probably on the order of 100 to 150 gpm. Estimates of potential yield, as based on specific-capacity frequency graphs, indicates that about 25 percent of the wells drilled in these units to depths of at least 200 feet in valleys may be expected to sustain yields of about 38 gpm, or more. About half of the wells drilled in valleys may be expected to sustain yields of about 18 gpm, or more.

Rock units rated as having poor potential for yielding water to wells include the Turkey Ridge member of the Marcellus Formation, the Montebello, Mifflintown, Rose Hill, Tuscarora, and Bald Eagle Formations. Most of these units underlie the crests and upper slopes of the principal mountains and ridges. Except for the Mifflintown Formation, which consists in part of limestone, these units are composed of non-calcareous sandstones and shales. The Keefer member of the Mifflintown Formation is a tough quartzitic sandstone which yields little water to wells. Maximum yields obtainable from wells in these units are probably on the order of 50 gpm in areas where these units are in the valleys of perennial streams.

HYDROLOGIC SIGNIFICANCE OF FRACTURE TRACES

It was noted in the section on geologic structure that fracture traces appear to be surface expressions of nearly vertical structural features—possibly zones of closely spaced fractures—in the underlying bedrock. It seems reasonable to assume, therefore, that wells drilled on these features might encounter zones of above-average permeability. Conclusive evidence to support this contention is not yet available. However, the exceptionally high yields of some wells drilled on or near fracture traces in carbonate rocks suggest that fracture traces may be very useful prospecting guides in this type of rock.

The specific capacities of 11 wells drilled on or near fracture traces in the carbonate rocks of the Nittany Valley in central Pennsylvania were found to be markedly higher than those of wells drilled between fracture-trace areas (Lattman and Parizek, 1964). The wells had specific capacities ranging from 1.8 to 236 gpm per ft, and eight of the wells had specific capacities greater than 10 gpm per ft after having been pumped for several hours at rates ranging from 458 to 1,650 gpm. The lowest specific capacities were determined for wells drilled on fracture traces on hillsides; the highest values were determined for wells in fracture traces in valley bottoms.

For the carbonate rocks of the Lebanon Valley in southeastern Pennsylvania, on the other hand, Meisler (1963, p. 33) found no relation between specific capacities and the location of wells with respect to fracture traces. Although his data include specific capacity tests for nearly 100 wells, none of the wells was intentionally drilled on a fracture trace. It is possible that

lack of correlation resulted from the circumstance that wells considered to be near fracture traces were, in fact, too far from the centerline of the trace to penetrate the fracture zone.

Evidence obtained from one of two test wells that were drilled on fracture traces during the present investigation lend support to the idea that these features may mark zones of high permeability in carbonate rocks. Well Ju-283, which was drilled to a depth of 375 feet on a fracture trace in argillaceous limestone of the Tonoloway Formation, has the highest specific capacity of the 79 wells tested during the study. Its specific capacity at the end of 1 hour's pumping at a rate of 102 gpm was 63 gpm per ft. Only four of the 79 wells tested had specific capacities greater than 10 gpm per ft.

Results obtained from test well Pe-466, which was drilled on a fracture trace in calcareous shale of the Wills Creek Formation, were not so encouraging. The well had a specific capacity of 0.76 gpm per ft after being pumped for 1 hour at a rate of 21.7 gpm, which is about average for wells in this formation.

Further studies are needed to fully determine the hydrologic significance of fracture traces in both carbonate and non-carbonate rocks. However, preliminary results indicate that the fracture-trace technique of locating zones of high bedrock permeability has considerable potential.

Many of the most prominent fracture traces that are visible on areal photographs of the Loysville and Mifflintown quadrangles are located on hillsides or hilltops underlain by carbonate rocks. Wells drilled on these traces, however, are likely to encounter a substantial thickness of highly weathered material and are likely to require more than average amounts of casing. Although wells drilled on these fracture traces may give higher than average yields, deeper water levels and lack of a source of recharge from a nearby stream make such sites less favorable than fracture traces located in valleys drained by a perennial stream.

WATER QUALITY

The type of mineral matter that becomes dissolved in ground water is determined largely by the composition of the soil and rock through which the water flows between points of recharge and discharge. The amount of mineral matter that becomes dissolved as water moves through the subsurface generally is determined by such factors as the solubility of the soil and rock, the duration of contact, and subsurface temperatures and pressures. Human activities such as on-lot disposal of sewage, the use of fertilizers on croplands, and the accidental spillage or leakage of chemicals also may affect the chemical composition of ground water.

The source and significance of the principal mineral constituents commonly dissolved in ground water are given in Table 9. The dominant cations

Table 9.—Source and significance of dissolved mineral constituents and properties of water

Constituent or property	Source or cause	Significance
Silica (SiO_2)	Dissolved from practically all rocks and soils. (Commonly less than 30 mg/1)	Forms hard scale in pipes and boilers; inhibits deterioration of zeolite-type water softeners.
Iron (Fe)	Dissolved from practically all rocks and soils. May also be derived from iron pipes, pumps, and other equipment.	On exposure to air, iron in ground water oxidizes to reddish-brown precipitate. More than about 0.3 mg/1 srains laundry and utensils reddish brown. Objectionable for food processing, textile processing, beverages, ice manufacturing, brewing, and other processes. Maximum limit recommended for drinking water is 0.3 mg/1.[1]
Manganese (Mn)	Dissolved from many rocks and soils. Often found associated with iron in natural waters but not as common as iron.	More than 0.2 mg/1 precipitates upon oxidation. Manganese has the same undersirable characteristics. as iron but is more difficult to remove. Maximum limit recommended for drinking water is 0.05 mg/1.
Calcium (Ca) and Magnesium (Mg)	Dissolved from practically all rocks and soils, especially from limestone, dolomite, gypsum, and their associated soils.	Cause of most of the hardness and scale forming properties of water (see hardness). Water low in calcium and magnesium are desired in electroplating, tanning, dyeing, and in textile manufacturing. Cause scale formation in steam boilers, water heaters, and pipes.
Sodium (Na) and Potassium (K)	Dissolved from practically all rocks and soils. Sewage and industrial wastes are also major sources. Most home water softeners replace soluble hardness-producing minerals with sodium and, thus, increase the amount of sodium present.	Concentrations of less than 50 mg/1 have little effect on the usefulness of water for most purposes. More than 50 mg/1 may cause foaming in steam boilers.

Bicarbonate (HCO_3) and Carbonate (CO_3)	Results from reaction of carbon dioxide in water with carbonate rocks and minerals. Decaying vegetation, sewage, and industrial wastes are also important sources.	Bicarbonate and carbonate produce alkalinity. Bicarbonates of calcium and magnesium decompose in steam boilers and hot water facilities to form scale and release corrosive carbon-dioxide gas. In combination with calcium and magnesium, cause carbonate hardness (see hardness).
Sulfate (SO_4)	Dissolved from rocks and soils containing gypsum, iron sulfides, and other sulfur compounds. Commonly present in mine waters, some industrial wastes, and sewage.	Sulfates of calcium and magnesium cause permanent hardness and form a hard scale in steam boilers and hot water pipes (see hardness). The maximum limit recommended for drinking water is 250 mg/1.[1]
Chloride (Cl)	Dissolved from rocks and soils. Relatively large amounts are derived from sewage, industrial wastes, and ancient brines.	In large quantities, increases the corrosiveness of water. Large amounts in combination with sodium will give a salty taste. Maximum limit recommended for drinking water is 250 mg/l.[1]
Fluoride (F)	Dissolved in small to minute quantities from most rocks and soils. Added to some waters by fluoridation of public water supplies	About 1.0 mg/l of fluoride in drinking water is believed to be helpful in reducing the incidence of tooth decay in small children; larger concentrations possibly cause mottling of enamel.
Nitrate (NO_3)	Decaying organic matter, sewage, and fertilizers are principal sources.	Small concentrations have no effect on usefulness of water. Most ground waters contain less than 10 mg/l. Waters containing more than 45 mg/l may cause methoglobinemia (an often fatal disease in infants) and, therefore, should not be used in infant feeding. Maximum limit recommended for drinking water is 45 mg/l.[1]
Dissolved solids	Chiefly mineral constituents dissolved from rocks and soils. Concentrations in natural waters may be increased from sewage, fertilizers, industrial wastes, and other man-made sources.	The maximum limit recommended for drinking water is 500 mg/l but water containing up to 1,000 mg/l may be used where less mineralized supplies are unavailable.[1] Waters containing more than 1,000 mg/l are unsuitable for many purposes.

Table 9.—Source and significance of dissolved mineral constituents and properties of water—Continued

Constituent or property	Source or cause	Significance
Hardness (as $CaCO_3$)	In most waters nearly all the hardness is due to calcium and magnesium. All of the metallic cations other than the alkali metals, also cause hardness. There are two classes of hardness—carbonate (temporary) and non-carbonate (permanent) hardness. Carbonate hardness refers to the hardness resulting from cations in association with carbonate and bicarbonate; noncarbonate hardness refers to that resulting from cations in association with other anions.	Consumes soap before a lather will form. Deposits soap curds on bathtubs. Hardness causes scale to form in boilers, water heaters, radiators, and pipes, causing a decrease in heat transfer and restricted flow of water. Carbonate hardness can be reduced by water softeners; noncarbonate hardness cannot readily be removed. Waters of hardness up to 60 mg/l are considered soft; 61 to 120 mg/l, moderately hard; 121 to 180 mg/l, hard; more than 180 mg/l, very hard.
Specific conductance (micromhos at 25° C)	Mineral content of water.	Specific conductance is a measure of the capacity of the water to conduct an electric current. It varies with concentration and degree of ionization of the constituents. May be used to obtain a rapid determination of the approximate dissolved-solids content of water.
Hydrogen-ion concentration (pH)	Water with a dominance of acids, acid-generating salts, and free carbon dioxide has a low pH. If carbonates, bicarbonates, hydroxides, phosphates, and silicates are dominant, the pH is high. (The pH of most natural waters ranges between 6 and 8.)	A pH of 7.0 indicates neutrality of a solution. Values higher than 7.0 denote increasing alkalinity; values lower than 7.0 indicate increasing acidity. pH is a measure of the activity of the hydrogen ions. Corrosiveness of water generally increases with decreasing pH. However, excessively alkaline waters may also attack metals.
Alkyl benzene sulfonate (ABS)	The principal sources of ABS are synthetic household-detergent residues in sewage and waste waters.	High concentrations of ABS cause undesirable taste, foaming, and odors. Presence of ABS in ground-water supplies may indicate bacterial pollution. The maximum limit recommended for drinking water is 0.5 mg/l.[1]

(positively charged ions) present in ground water from the Loysville and Mifflintown quadrangles are calcium and magnesium; the dominant anion (negatively charged ion) is generally bicarbonate. Sulfate is the dominant anion in water from a few wells in the Tonoloway and Wills Creek Formations. These wells apparently tap beds containing gypsum or other highly soluble sulfate minerals.

Evaluation of the quality of ground water in the Loysville and Mifflintown quadrangles is based on a study of (1) chemical analyses of water from 34 wells, as listed in Table 10; (2) field values of hardness and specific conductance that were determined at more than 300 wells, iron determined at 41 wells; and (3) laboratory determinations of nitrate and chloride and field determinations of bacterial content of water samples collected from 22 wells in and near the unsewered communities of Landisburg, Loysville, and Ickesburg.

Ground water in the Loysville and Mifflintown quadrangles generally is of good chemical quality. The water commonly contains low to moderate amounts of dissolved solids, and—except for bothersome concentrations of iron, hydrogen sulfide gas, and hardness in some localities—contains no constituents that significantly impair its use for most purposes. Water from calcareous shales and limestones of Late Silurian and Early Ordovician age generally has a dissolved-solids content of 200 to 300 mg/l (milligrams per liter) and is usually very hard. (See Table 9 for description of hardness.) Water from the predominantly noncalcareous shales, siltstones, and sandstones generally has a dissolved-solids content of 100 to 200 mg/l and is soft to moderately hard.

Alteration of the natural chemical quality of ground water by man has been minimal. A few wells have been contaminated by gasoline or fuel oil that has leaked from buried storage tanks. Small to moderate quantities of nitrate, chloride, and other constituents derived from sewage have been added to ground water in the vicinity of most cesspools and septic-tank drain fields. Small quantities of nitrate, chloride and other constituents have been added to the ground water from fertilizers spread on croplands. Some wells are known to be bacterially contaminated, particularly shallow hand dug wells, but no widespread problems of bacterial contamination are known to exist.

A comparison of minimum, median, and maximum concentration of chemical constituents in water from predominantly calcareous and noncalcareous rock units is shown in Table 11. These data indicate that the waters from different aquifers differ mainly in the amount of hardness-forming constituents present. The median calcium-magnesium hardness (the equivalent of total hardness) of water from units composed predominantly of calcareous shale and limestone is 218 mg/l is compared to a median of only 72 mg/l for water from units composed predominantly of

Table 10.—*Chemical analyses of ground water*
(Results in milligrams per liter, except as indicated)

Aquifer: Df, Fort Little on Formation, Dr, Rush Formation; Ds, Sherman Ridge Formation; Dmh, Mahantango Formation; Dmm, Marcellus Formation, Mahanoy Member; Dmt, Marcellus Formation, Turkey Ridge Member; Don, Onondaga Formation; Sk, Keyser Formation; Sto, Tonoloway Formation; Swu, Wills Creek Formation, upper member; Swl, Wills Creek Formation, lower member; Sb, Bloomsburg Formation; Smm, Mifflintown Formation, McKenzie and Rochester Members, undivided; Or, Reedsville Formation; Om, Martinsburg Formation.

Well number	Aquifer	Date of collection	Temperature (F)	Silica (SiO_2)	Total iron (Fe)	Total manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (residue at 180° C)	Hardness as $CaCO_3$: Calcium Magnesium	Hardness as $CaCO_3$: Non-carbonate	Specific conductance (micromhos at 25° C)	pH (lab)	Color
Cumberland County																					
Cu-150[a]	Om	6-26-62	—	—	0.8	0.2	15.2	6.8	—	—	—	0	2.4	—	0	196	66	—	—	7.1	25
155	Om	3-22-66	55	23	.11	.18	40	12	8.2	1.6	168	26	1.8	.2	1.0	196	150	12	333	7.5	4
Juniata County																					
Ju- 11[b]	Sto	8-20-34	53	12	.04	—	82	25	35	2.2	286	51	61	—	11	429	[c]308	—	—	—	—
12[b]	Sto	8-23-34	53	—	.05	—	94	40	[c]10	—	433	50	3.0	—	11	421	399	—	—	—	—
13[b]	Sb	8-20-34	54	—	.37	—	86	24	[c]5	—	308	20	17	—	34	[c]338	[c]313	—	—	—	—
72[d]	Swl	9-14-53	—	—	.1	—	—	—	—	—	341	—	1	—	—	320	300	20	—	7.3	0
73[d]	Sto	6-12-61	—	—	.4	—	—	—	—	—	201	—	2	—	—	280	205	40	—	7.8	0
75	Swl	5-19-65	51	7.9	.41	.05	21	4.6	.4	.2	84	2.6	.7	.0	.4	83	72	2	139	6.9	1
76[d]	Swl	7-14-55	—	—	.1	—	—	—	—	—	96	—	2	—	—	100	80	1	—	6.2	5
96	Sb	6-18-65	49	11	.62	.01	27	6.9	6.0	.6	128	4.2	2.2	.0	.5	125	96	0	214	7.5	3
105[a]	[f]Or	1964	—	—	—	—	40	21	140	8	250	155	113	—	—	—	186	0	1,030	7.3	—
143	Sk	4-18-66	—	7.9	.12	.00	74	7.6	2.5	.5	176	21	11	.1	44	278	216	72	443	7.5	2
232	Smm	4-18-66	52	7.4	.48	.00	55	4.6	1.0	.5	154	10	4.8	.1	15	192	156	30	319	7.4	3
242	Sb	4-20-66	53	8.7	.12	.00	8.0	3.3	1.8	1.2	24	8.2	2.8	.0	11	71	34	14	93	6.1	2

Mifflin County																					
Mf- 54[b]	Dmt	8-14-34	53	—	.72	—	60	8.5	11		151	68	10	—	.20	232	185	61	—	—	—
106	Sto	4-20-66	—	7.4	.18	.00	66	26	.6	.7	290	38	4.0	.3	5.2	323	272	34	531	7.5	2
134	Dmh	4-20-66	53	12	.17	.03	8.2	3.3	34	.3	124	8.2	1.6	.3	.4	139	34	0	213	8.0	2
152	Or	12-29-65	49.5	15	.14	.52	26	6.1	7.8	1.1	129	1.0	.9	.2	1.0	122	90	0	204	7.2	2
214	Dmm	3-18-66	52	25	.37	.24	50	14	18	.8	218	48	1.1	.2	1.4	265	182	4	427	7.5	2
Perry County																					
Pe- 64[e]	Swl	1-11-33	—	—	0	—	—	—	—	—	225	—	14	—	6.0	—	260	75	—	7.3	0
71[e]	Swu	7-5-32	—	—	0	—	—	—	—	—	280	—	6	—	0	—	340	110	—	7.6	0
71[b]	Swu	8-25-34	53	—	.07	—	73	32	5		258	85	4.0	—	9.0	[c]335	[c]314	—	—	—	—
145	Swu	4-14-66	—	7.6	.10	.00	56	7.4	1.5	.9	168	15	4.4	.1	26	202	170	33	342	7.4	2
146	Sto	4-15-66	51	7.5	.09	.00	69	11	1.2	.8	212	21	4.3	.1	26	248	218	44	341	7.4	2
170	Swl	4-7-66	—	7.5	.09	.00	64	8.4	2.8	.8	178	23	10	.1	24	231	194	48	392	7.9	3
182	Don	4-7-66	—	11	.43	.05	101	15	2.9	1.3	299	55	14	.0	.4	363	314	69	596	7.5	3
190	Swu	4-14-66	—	4.7	.10	.00	46	6.3	.7	.8	140	12	3.4	.0	20	168	140	27	275	7.2	2
261	Df	4-15-66	—	16	.13	.00	14	8.8	22	1.8	44	4.2	28	.1	49	168	70	35	268	6.4	2
272	Ds	4-14-66	—	15	.19	.00	24	3.6	4.2	.7	76	18	1.4	.1	1.5	110	75	13	168	6.9	2
283	Dr	4-15-66	—	18	.39	.14	18	4.9	6.2	.7	72	8.2	9.0	.1	.3	103	66	6	164	6.9	2
309	Sr	5-16-66	—	9.3	.78	.31	9.5	5.7	2.6	.5	64	3.4	1.5	.0	.6	74	47	0	112	6.9	2
348[a]	Swu	8-13-52	—	38	—	—	—	—	—	—	163	—	—	—	—	—	154	20	—	7.6	—
396	Swl	4-6-66	54	11	.11	.00	74	32	8.8	2.3	284	37	28	.1	26	372	316	84	633	7.3	2
427	Dhs	6-29-66	52	9.8	.01	.00	42	3.8	.6	.2	141	3.8	1.8	.0	4.0	132	121	5	228	7.7	5
Snyder County																					
Sn- 89[a]	Sb	3-26-65	—	9.6	.7	—	16	2	—	—	195	63	32	—	—	300	44	0	—	7.6	5

[a] Analysis by private laboratory
[b] Lohman, 1938
[c] Calculated
[d] Analysis by Pennsylvania Department of Health
[e] Analyst unknown
[f] Gas test well sampled at a depth of 6,093 feet

Table 11.—Summary of chemical-quality characteristics of ground water from predominantly calcareous and noncalcareous rock units

Constituent or property	Predominantly calcareous rock units[1] Number of samples	Concentration[3] Minimum	Median	Maximum	Predominantly noncalcareous rock units[2] Number of samples	Concentration[3] Minimum	Median	Maximum	Maximum concentration recommended for drinking water (USPHS, 1962)
Silica (SiO_2)	12	4.7	7.9	38	12	7.4	13	25	—
Iron (Fe)	18	0	.09	.43	14	.11	.38	.78	0.3
Manganese (Mn)	10	.00	.00	.05	12	.00	.08	.52	.05
Calcium (Ca)	13	21	69	101	14	8.0	21	60	—
Magnesium (Mg)	13	4.6	11	40	14	2	5.9	14	—
Sodium (Na)	12	.4	2	35	11	1.0	6.2	34	—
Potassium (K)	11	.2	.8	2.3	11	.3	.7	1.8	—
Bicarbonate (HCO_3)	19	84	212	433	13	24	128	218	—
Sulfate (SO_4)	13	2.6	23	85	14	0	8.2	68	250
Chloride (Cl)	18	.7	4.2	61	14	.9	2.3	32	250
Fluoride (F)	10	.0	.1	.3	11	.0	.1	.3	[4]
Nitrate (NO_3)	15	0	11	44	13	0	1.0	49	45
Total dissolved solids (residue on evaporation)	16	83	320	429	14	71	153	300	500
Calcium magnesium hardness as $CaCO_3$	19	72	218	399	14	34	72	185	—
Concarbonate hardness as $CaCO_3$	16	1	37	110	13	0	6	61	—
Specific conductance (micromhos at 25° C)	10	139	367	633	11	93	213	427	—
pH	16	6.2	7.4	7.9	13	6.1	7.2	8.0	—

[1] Formation and number of samples: Helderberg (1); Onondaga (1); Keyser (1); Tonoloway (5); Wills Creek (11).

[2] Formation and number of samples: Fort Littleton (1); Rush (1); Mahantango (1); Sherman Ridge (1); Marcellus (2); Mifflintown (1); Bloomsburg (3); Rose Hill (1); Reedsville (1); Martinsburg (2).

[3] Concentrations in milligrams per liter, except specific conductance and pH.

[4] Recommended limits for fluoride vary according to the annual average of maximum daily air temperatures. Recommended upper limits [illegible] where the average maximum air temperature ranges between 50 and 53.7 [illegible] to 0.8 mg/l in areas where it ranges

noncalcareous shales, siltstones, and sandstones. The highest concentrations of iron occur generally in water from the noncalcareous rock units, as is indicated by the median concentration of 0.38 mg/l iron for wells in these units and the median of only 0.09 mg/l for wells in the calcareous rock units. Nitrate, on the other hand, is generally highest in ground water from calcareous rock units. The median nitrate content of water from the calcareous rocks is 11 mg/l compared to a median of only 1 mg/l for noncalcareous rock units.

Comparison of the chemical data in Table 11 with recommended limits for selected constituents in drinking water (U.S. Public Health Service, 1962) indicates that iron in water from noncalcareous rocks is the only constituent that commonly approaches or exceeds the recommended limits. However, nitrate does approach or exceed the recommended limit in a few wells.

SPECIFIC CONDUCTANCE AND TOTAL DISSOLVED SOLIDS

Specific conductance is a measure of the capacity of a material to conduct an electric current. In relatively dilute solutions, such as the shallow ground water in the study area, specific conductance is proportional to the concentration of ionized constituents. Specific conductance may be used, therefore, as a means of rapidly determining the approximate dissolved-solids content of water samples. The approximate dissolved-solids content, in milligrams per liter, of water from wells in the Loysville and Mifflintown quadrangles may be determined by multiplying the specific conductance values by 0.58. A water having a specific conductance of 100 micromhos, for example, would have a dissolved-solids content of about 58 mg/l.

Specific conductances of water from more than 300 wells are summarized by geologic formation and member in Table 12 and listed for individual wells in Table 6. These data show that the median specific conductances of water from the formations and members composed predominantly of noncalcareous rocks (those units stratigraphically below the Wills Creek Formation and stratigraphically above the Onondaga Formation) range between 90 and 360 micromhos. These values are equivalent to about 50 and 210 mg/l of dissolved solids, respectively. The median specific conductances of water from units composed predominantly of calcareous rocks (those units stratigraphically between and including the Wills Creek and Onondaga Formations) range between 170 and 550 micromhos. These values are equivalent to about 100 and 320 mg/l of dissolved solids, respectively.

The lowest specific conductance for each rock unit is less than 300 micromhos, which indicates that water containing less than 175 mg/l total dissolved solids can be obtained from some wells in each formation.

The maximum recommended limit for dissolved solids in drinking water is 500 mg/l (U.S. Public Health Service, 1962) which is equivalent to a

Table 12.—Field determinations of hardness and specific conductance

Formation	Member	Map symbol	Dominant rock type[1]	Hardness[2] (grains per gallon)			Specific conductance (micromhos at 25° C)[3]		
				Number of wells	Median	Range	Number of wells	Median	Range
Fort Littleton		Df	ss, sh	8	4	3–9	8	230	160–180
Rush		Dr	sh	6	4	4–7	6	240	185–300
Sherman Ridge		Dms	sh, ss	10	4	3–6	8	190	150–220
Mahantango		Dmh	sh, ss	23	5	2–8	23	225	100–365
Montebello		Dmoo Dmom, Dmot	ss	13	4	1–10	13	150	55–430
Marcellus		Dm	sh, ss	2	—	8–9	2	—	280–360
	Mahanoy	Dmm	sh	7	6	5–14	7	270	215–620
	Turkey Ridge	Dmt	ss	12	6	1–9	12	265	100–400
	Shamokin	Dms	sh	9	10	1–11	9	360	80–470
Onondaga		Don	ls, calc. sh	6	10	5–17	6	480	170–740
Old Port		Do	ls, ch, ss	9	2	2–6	9	170	55–260
Oriskany	Ridgeley	Dor	ss	1	1	—	2	—	45–60

Oriskany and Helderberg	Schiver —	Dhs	ls, ch	4	7	6–9	4	290	260–320
Keyser		Sk, Sky	ls	11	15	6–50	10	430	215–1,050
Wills Creek		Sw	calc. sh	10	9	2–27	10	310	85–840
	Upper	Swu	calc. sh	21	15	4–25	23	550	175–2,100
	Lower	Swl	calc. sh	32	10	1–27	31	400	50–1,075
Bloomsburg		Sb	sh, ss	46	5	1–18	44	230	40–900
Mifflintown		Sm	sh, ls	5	8	3–11	5	310	180–425
	McKenzie and Rochester	Smm	sh, ls	9	7	2–11	9	325	55–460
	Keefer	Smk	ss	3	4	3–4	3	240	100–510
Rose Hill		Sr	sh, ss	10	5	4–20	10	200	165–4,000
Tuscarora		St	ss	3	2	1–5	3	90	40–220
Reedsville and Martinsburg		Or, Om	sh	23	6	1–9	22	220	30–370

[1] Calcareous shale, calc. sh; chert, ch; sandstone, ss; shale, sh; limestone, ls.

[2] Multiplying these values by 17 gives the approximate hardness (as $CaCO_3$) in milligrams per liter. Hardness in gpg (grains per gallon) may be classified approximately as follows: soft, 1-3 gpg; moderately hard, 4–7 gpg; hard, 8–11 gpg, very hard, more than 11 gpg.

[3] Multiplying these values by 0.58 gives the approximate concentration of dissolved solids in milligrams per liter.

specific conductance of about 860 micromhos. Only 3 percent of the water samples examined had a specific conductance of 860 or more, and most of these were from limestone of the Tonoloway Formation or from the calcarcous shale of the Wills Creek Formation. Thc high conductances are caused principally by the prescnce of hardness-forming constituents.

Locally, the dissolved-solids content of ground water undoubtedly has been increased somewhat above natural levels as a result of the addition of chemical constituents derived from sewage effluent, septic tanks and cesspools, fertilizers spread on croplands, and other man-made sources of contamination.

HARDNESS

Field determinations of hardness of water from 321 wells are summarized by geologic formation and member in Table 12 and listed for individual wells in Table 6. The determinations were made in grains per gallon (gpg). They may be converted to approximate concentrations of hardness in milligrams per liter by multiplying them by a factor of 17.

Ground water from the predominantly noncalcareous rock units that lie stratigraphically below the Wills Creek Formation and above the Onondaga Formation is generally soft (1 to 3 gpg) to moderately hard (4 to 7 gpg). Ground water from the calcareous shales and limestones that dominate the stratigraphic interval between thc Wills Creek and Onondaga Formations is generally hard (8 to 11 gpg) to very hard (more than 11 gpg).

Ground water has a considerable range in hardness in most rock units, particularly those composed of calcareous shale or limestone. Water from wells in the limestone of the Tonoloway Formation, for example, ranged in hardness from 6 to 60 gpg. The range in hardness values shown in Tables 10 and 12 indicates that soft to moderately hard water is obtainable from cach formation.

The hardest water generally occurs in the calcareous shales and limestones of the Wills Creek, Tonoloway, and Keyser Formations. Some wells in the Wills Creek and Tonoloway Formations yield excessively hard water that apparently is derived from beds containing gypsum or an other highly-soluble sulfate mineral. For example, field determinations of hardness and sulfate content of water from test well Ju-283, which was drilled in the Tonoloway Formation, indicated that the water had a hardness of 60 gpg and a sulfate content in excess of 800 mg/l.

IRON AND MANGANESE

Iron and mangancse, which resemble each other in chemical behavior, are generally present in ground water in small concentrations. Even in minor concentrations, however, these constituents may have a marked

effect on the utility of water. Individual or combined concentrations of iron and manganese in excess of 0.3 mg/l may cause stains on plumbing fixtures, cooking utensils, and laundry; concentrations greater than 1 mg/l may cause clogging of pumps, water-distribution systems, and plumbing fixtures.

Iron was reported to be present in noticeable or bothersome amounts in many of the rock units studied, but was most commonly reported to be present in water from wells in the noncalcareous shales and sandstones. The rock units for which the most reports of bothersome amounts of iron were received include the Martinsburg Formation (shale and siltstone), the Turkey Ridge Member of the Marcellus Formation (sandstone), and the Mahantango Formation (interbedded sandstone, siltstone, and shale).

Analyses for iron are available for water from 72 wells. Forty-one of the analyses were determined in the field during this study and 15 of them were for wells in the Martinsburg Formation. The concentration of iron in the combined population of laboratory and field determinations ranges from 0.01 to 2.6 mg/l.

Iron in 28 samples of water from the predominantly calcareous rocks, comprising the stratigraphic interval between, and including, the Wills Creek and Onondaga Formations, ranged from 0.01 to 0.8 mg/l and the median concentration was 0.1 mg/l. The limit of 0.3 mg/l recommended for drinking water was exceeded in 8 (29 percent) of the samples.

Iron in 44 samples of water from the predominantly noncalcareous rocks, lying stratigraphically below the Wills Creek Formation and above the Onondaga Formation, ranged from 0.05 to 2.6 mg/l and the median was 0.4 mg/l. Iron exceeded 0.3 mg/l in 25 (57 percent) of the samples, 13 of which were from the Martinsburg Formation.

The iron concentrations present in ground water from the Loysville and Mifflintown quadrangles are not excessive and may be removed by treatment at a reasonably low cost.

Manganese ranges from 0.00 to 0.52 mg/l in 22 samples for which this constituent was determined. None of the 10 samples from calcareous rock units yielded water containing more than 0.05 mg/l, the limit recommended for drinking water by the U.S. Public Health Service (1962). Six of the 12 samples of ground water from the predominantly noncalcareous rock units contained managanese in excess of this amount.

HYDROGEN SULFIDE

The "rotten egg" odor of hydrogen sulfide gas was reported to be present in water from several wells that penetrate shales of the Martinsburg and Reedsville Formations, and from shales of the Marcellus, Sherman Ridge, Mahantango, Rush, and Fort Littleton Formations. No measurements were made for this constituent, but a strong odor may result from concentrations of less than one part per million. Hydrogen sulfide is distasteful but harmless in drinking water, and waters containing it are generally slightly acidic.

NITRATE AND CHLORIDE

Concentrations of nitrate and chloride present in ground water that has remained unaffected by human activities are generally low and have little affect on the utility of the water for most purposes. In humid areas, concentrations of these two constituents in ground water generally are less than 10 mg/l.

Several of the wells sampled for this study are near septic tanks, cesspools, barnyards, or heavily fertilized fields, which constitute a man-made source of nitrate and chloride in ground water. As a result, the concentrations of these constituents may be higher than natural levels. The median concentrations of nitrate and chloride shown for ground water from predominantly calcareous and noncalcareous rock units (see Table 11) are probably fairly representative of the average concentrations present in ground water throughout most of the study area. The median chloride content of ground water is less than 5 mg/l in both groups of rocks. The median concentration of nitrate is 11 mg/l in ground water from the calcareous rock units, but is only 1.0 mg/l in ground water from noncalcareous rock units. The higher median concentration for nitrate in water from calcareous rock units may be due in part to extensive fertilization of the intensively cultivated soils overlying these rock units.

The contents of nitrate and chloride was determined for ground-water samples from 22 wells located in or near the communities of Landisburg, Loysville, and Ickesburg in the Loysville quadrangle. As these communities have been served by individual wells and on-lot sewage-disposal systems for many years, the concentrations determined (see Table 13) give some idea of the magnitude of buildup of these two constituents that can be expected to occur over long periods of time in other unsewered communities in and near the study area. The median values for both nitrate and chloride is 22 mg/l, which is below the maximum limits of 45 and 250 mg/l, respectively, recommended for drinking water by the U.S. Public Health Service. Although concentrations varyed widely, only two of the samples contained nitrate in excess of recommended limits. Nitrate concentrations range from 1.2 to 116 mg/l; chloride concentrations ranged from 3.0 to 124 mg/l. Both of the samples containing excessive nitrate were from shallow, hand-dug wells in the community of Landisburg. One of these wells (Pe-549), which yielded water containing 70 mg/l nitrate, is only 50 feet from a drilled well (Pe-107) that yielded water containing only 30 mg/l nitrate. The drilled well is 130 feet deep and is cased and grouted to a depth of 53 feet.

The presence in ground water supplies of nitrate and chloride derived from sewage does not necessarily indicate that the water contains bacterial organisms derived from the same source. Bacterial organisms may be filtered from sewage effluent as it percolates for short distances through soil and rock, whereas chloride and nitrate generally persist and are diminished mainly by dilution.

Well number	Type of well	Well depth (feet)	Casing depth (feet)	Water level		Date sampled	Chemical quality				Bacteriological quality		
				Date	Depth		Specific conductance (micromhos at 25° C)	Hardness (grains per gallon)	Nitrate (mg/l)	Chloride (mg/l)	Size of sample	Number of coliform	Coliform per 100 ml
Landisburg Area													
Pe- 96	Drilled	72	19	Oct. 1964	10	11- 3-66	540	16	7.2	28	50 100	38 57	76 67
Pe-107	Drilled	130	53	Dec. 1963	35	11- 3-66	950	24	30	97	50 100	0 0	0 0
						4- 6-67	1,030	23	—	—	100 200	0 0	0 0
Pe-110	Drilled	190	28	Oct. 1963	25	11- 3-66	—	—	1.2	3.0	50 100	0 1	0 1
						4-11-67	315	4	—	—	100 200	0 0	0 0
Pe-117	Drilled	125	39	Aug. 1963	65	11-16-66	630	15	6.6	10	50 100	0 0	0 0
						4- 6-67	580	15	—	—	100 200	7 2	7 1
Pe-153	Drilled	130	45	June 1965	72	11- 3-66	465	13	41	15	50 100	0 0	0 0
						4-11-67	560	13	—	—	100 200	1 3	1 1.5
Pe-169	Drilled	115	33	—	26	11-16-66	800	19	22	51	50 100	0 0	0 0
						4-11-67	800	19	—	—	100 200	0 0	0 0
Pe-445	Drilled	98	56	July 1966	20	11-16-66	400	10	13	6	50 100	0 1	0 1
						4-11-67	450	11	—	—	100 200	0 0	0 0
Pe-459	Dug	18	—	Oct. 1966	6	10-27-66	—	—	70	22	1 10	1 16	100 160
						4-6-67	740	14	—	—	10 50	0 11	0 22
Pe-460	Dug	22	—	Oct. 1966	9	10-7-66	1,175	21	116	92	10 50	— >80	— >160

Table 13.—Bacterial and chemical quality of water from wells in or near the unsewered communities of Loysivlle, Landisburg, and Ickesburg—Continued

Loysville Area													
Pe-127	Drilled	131	61	Nov. 1961	95	11-14-66	300	8	22	4	50 100	0 0	0 0
						4-11-67	320	7	—	—	100 200	0 0	0 0
Pe- 63	Drilled	103	43	Oct. 1958	40	11-16-66	615	15	32	32	50 100	2 2	2 4
						4-11-67	625	13	—	—	100 200	2 1	2 0.5
Pe-168	Drilled	100	40	Aug. 1958	26	11-14-66	840	15	7.2	124	50 100	18 51	36 51
Pe-170	Drilled	100	62	May 1958	35	11-14-66	335	11	22	10	50 100	0 0	0 0
						4-11-67	415	9	—	—	100 200	0 0	0 0
Pe-413	Drilled	140	68	June 1966	86	11-14-66	300	9	25	6.0	50 100	0 0	0 0
						4-11-67	330	9	—	—	100 200	0 0	0 0
Pe-461	Drilled	106	27	Nov. 1966	29	11-16-66	750	16	12	116	50 100	6 26	12 26
Ickesburg Area													
Pe-341	Drilled	49	—	Aug. 1965	16.6	11-8-66	490	17	24	17	10 50	0 2	0 4
Pe-305	Drilled	211	18	July 1958	6	11-8-66	830	20	22	72	50 100	3 3	6 3
Pe-359	Drilled	100	28	—	—	11-8-66	680	17	0.7	70	10 50	0 1	0 2
Pe-417	Drilled	81	40	May 1966	8	11-8-66	260	6	9.4	3.5	50 100	0 0	0 0
						4-11-67	210	5	—	—	100 200	0 0	0 0
Pe-500	Drilled	43	20	Aug. 1966	7	10-13-66	690	17	23	40	50 100	31 60	62 60
Pe-501	Dug	20	—	—	—	11-8-66	980	18	24	39	10 20	30 40	300 200
Pe-502	Dug	20	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

ALKYL BENZENE SULFONATE (ABS)

Alkyl benzene sulfonate is a synthetic organic chemical used in household detergents. In areas where sewage is discharged into the ground by means of septic tanks and cesspools, considerable quantities of this constituent may be introduced into the ground-water reservoir. The presence of small amounts of ABS in drinking water causes no toxic effects in humans, but concentrations of more than 0.5 mg/l may cause an undesirable taste, frothing, and may signal the presence of bacterial pollution. No tests were made for ABS. However, since none of the wells inventoried was reported to yield water that frothed noticeably, it is likely that ABS, where present, occurs in amounts of less than 0.5 mg/l.

WATER QUALITY PROBLEMS

Water quality problems in the Loysville and Mifflintown quadrangles generally are confined to individual wells, and in most instances may be corrected either by treatment of the water or by improving the construction of the well. Troublesome or bothersome constituents most commonly reported to be present in ground-water supplies include iron, hydrogen sulfide, hardness, bacterial organisms from sewage, and petroleum products derived from buried storage tanks.

Excessive iron, hydrogen sulfide, and hardness in water from existing wells generally may be eliminated or reduced only by treating the water. During the construction of new wells, however, it may be possible to locate and case off zones that yield water of poor quality. Identification of the offending yielding zone, or zones, may be accomplished by frequent sampling of the well discharge as a well is being deepened. For example, during the construction of test well Ju-283, the hardness of the water at a depth of 136 feet was 64 grains per gallon (approximately 1,090 mg/l); at a depth of 200 feet the hardness had decreased to 32 gpg, approximately 545 mg/l, indicating that water of considerably better quality enters the well below a depth of 136 feet. Casing this well to a depth of 136 feet would reduce the yield substantially but would greatly improve the quality of the water.

Most instances of contamination of well supplies by petroleum products were caused by leakage of fuel oil or gasoline from buried storage tanks. Although most such leaks have been stopped, gasoline or fuel oil has continued to seep to some nearby wells for several years. Well Pe-212 in the community of Landisburg, for example, was reported to have been contaminated in 1954 by gasoline that leaked from a buried tank about 70 feet away. The well, which is 107 feet deep and contains an unknown amount of casing, still smelled strongly of gasoline in 1967. A new well (Pe-171) drilled about 120 feet from the buried tank and about 50 feet from Pe-212, yields water free of gasoline. The new well is cased to a depth of 41 feet. Casing in well Pe-212

is highly corroded and probably leaks. Because petroleum products float on the water table, deep casing generally will eliminate them from a well supply so long as the water level in the well is not drawn down below the bottom of the casing for prolonged periods.

Bacterial Contamination Of Wells

Bacterial contamination of well water is possible in any area where sewage is discharged into the ground near a well. The possibility of contamination is especially great, however, in communities of closely spaced homes that have on-lot disposal systems. The close spacing of septic-tank leach fields, cesspools, or other disposal systems, and the unavoidable placement of some wells on the downslope from sewage-disposal systems on adjacent lots, may result in bacterial contamination of ground water at shallow depths around many drilled wells. These wells may become contaminated if they contain too little casing, or if the annular opening around the exterior of the casing is not tightly sealed.

Other conditions, of course, may be responsible for the bacterial contamination of a drilled well. Contaminated water may enter a faultily constructed well, move downward to a deep water-bearing zone, and then move laterally through fractures to a nearby well that is otherwise adequately cased and sealed. Introduction of sewage wastes to the bedrock, either where bedrock is close to land surface or where it is penetrated by deep cesspools, may result in the condition where the sewage effluent receives too little filtration and decomposition to remove all bacterial organisms before it reaches a nearby well.

Dug wells and springs in areas of closely spaced homes are highly susceptible to bacterial contamination. Their use for drinking and culinary supplies should be avoided, unless periodic examination has shown them to be free of sewage-derived bacteria. All well supplies, of course, should be tested periodically for bacterial content.

Water samples from 22 wells were tested for coliform bacteria, nitrate, and chloride during the fall of 1966. Twelve of the wells were retested for bacteria during the spring of 1967. Results of the tests are given in Table 13.

Four of the wells sampled are hand-dug wells that range from 18 to 22 feet in depth. The other 18 wells are drilled and range from 43 to 211 feet in depth. These wells are cased to depths ranging from 18 to 68 feet. All of the wells sampled are in or near the unsewered communities of Loysville, Landisburg, and Ickesburg.

Tests for coliform organisms were made by the membrane filter technique. A sample was considered to be contaminated if it contained more than 2.2 coliform organisms per 100 milliliters. No published standards are available that give the acceptable level of coliform bacteria in drinking water from domestic wells, on the basis of the analysis of single samples. However, the

Pennsylvania Department of Health considers water from domestic wells to be unsafe for drinking if more than 2.2 coliform bacteria per 100 milliliters are present in two consecutive samples.

Water samples from the four dug wells were grossly contaminated by coliform bacteria, suggesting that ground water at shallow depths in these communities may be generally contaminated. Eight of the drilled wells also were contaminated. Casing depths in seven of these drilled wells ranged from 18 to 49 feet and the median depth was 39 feet. The annular space around the most deeply-cased contaminated well was grouted with cement. Casing depths in the 10 uncontaminated wells ranged from 28 to 68 feet and the median depth was 49 feet.

Results of tests of two wells, which are spaced only a short distance apart in the community of Landisburg, illustrate the effectiveness of adequate casing and a tight casing seal in preventing bacterial contamination of a well supply. Well Pe-107 is 130 feet deep, is cased and grouted with cement to a depth of 53 feet, and had a static water level 35 feet below land surface in December, 1963. Approximately 40 feet away, at about the same altitude, is well Pe-459, which is dug to a depth of 18 feet and in which the static water level was 6 feet below land surface in October, 1966. The water levels, although measured during different years, were measured during the same season and, thus, would indicate a general difference in head of about 30 feet, between the two wells. The large difference in head that exists between the two wells would cause shallow ground water to flow into the drilled well if its casing were too short or if the casing seal leaked. Bacteriological tests of water from the two wells, on two occasions, showed that the water in the dug well was grossly contaminated, but no bacterial organisms were present in water from the drilled well. This situation indicates that no direct inflow occurs around the casing of the drilled well. The relatively high nitrate content of 30 mg/l in water from the drilled well does indicate, however, that the chemical quality of the ground water is affected by the disposal of sewage into the ground nearby.

Data from this study are insufficient to establish the minimum casing length necessary to prevent bacterial contamination of a well. In some instances, contamination may be unpreventable unless nearby wells are properly cased and sealed. In areas of closely spaced homes, it appears advisable to case and grout wells to a depth of at least 50 feet.

WATER USE

Development of both ground- and surface-water resources has been minor in the Loysville and Mifflintown quadrangles. Most water is used for residential or farm needs. Very little water is used for irrigation, and much of the water used by commerce and industry is used for sanitary purposes.

Only five communities—Mifflin, Mifflintown, McAlisterville, McClure, and Port Royal—are served by public distribution systems. The amount of water distributed in 1964 by the four water-supply facilities that serve these communities is shown in Table 14. Approximately 27 percent of the water distributed was obtained from wells; the remainder was obtained from streams and springs. The Mifflintown Municipal Authority obtained its entire supply from reservoirs on Licking Creek and Macedonia Run. The other facilities obtained their water from wells and springs.

Average daily usage during 1964 amounted to 0.19 mgd (million gallons per day), which for the 6,200 people served is equivalent to a per capita use of about 30 gallons per day. This relatively low value reflects the dominant use of the water for residential needs. The national average usage of water in areas served by public water-supply systems was 151 gallons per day per person in 1960 (MacKichan and Kammerer, 1961, p. 4).

Most users that are not on public-supply systems obtain their water from drilled wells, although a few supplies are obtained from springs and shallow hand-dug wells.

The communities of Mifflin, Mifflintown, and Port Royal are served by sewer systems. Water supplied to these areas from streams, springs, or wells is used, treated, and discharged into the Juniata River. Elsewhere in the study area, much of the water pumped from wells and springs is used and returned to the ground-water reservoir by means of septic tanks or cesspools. This water is partially reconditioned by the soil and rock through which it moves before it becomes available for reuse.

CONCLUSIONS

The ultimate source of all ground and surface water in the Loysville and Mifflintown quadrangles is precipitation, which ranges from 26 to 62 inches annually and averages about 41 inches annually. Simple water budgets computed for four drainage basins that include parts of the study area indicate that 54 to 60 percent of the average annual precipitation is consumed by evaporation and plant transpiration. Part of the remainder flows over the land surface to nearby streams, and part of it infiltrates to the water table and flows very slowly to streams through fractures in the bedrock. Ground water discharge to a stream that drains a 15-square mile area in the Loysville quadrangle accounted for 58 percent of the average annual flow over an 11-year period.

Despite the proportionately large ground-water contribution to streamflow, low specific capacities of wells and low reported yields of wells in all rock units indicate that the permeability of the bedrock is relatively low.

The ground-water reservoir in the study area consists of the saturated parts of the saprolite and zone of open fractures in the bedrock. The saprolite

Table 14.—Water distributed by public-supply systems during 1964[a]

Name of facility	Estimated population served	Number of customers	Millions of gallons sold	Estimated percentage obtained from wells	Type of use (in percent)				Per capita usage (gpd)
					Residential	Commercial	Industrial	Other	
McAlisterville Water Authority	700	251	[b]13.8	50	84	14	2	—	54
Mifflintown Municipal Authority	3,500	981	[c]37.2	0	46	34	15	5	29
Port Royal Municipal Authority	1,000	348	[b]12.5	70	96	2	—	2	34
West Beaver Municipal Authority (serves McClure)	1,000	332	[c]6.9	50	81	9	4	6	19

[a] Data obtained in part from Pennsylvania Department of Commerce, Bureau of Statistics.
[b] Unmetered.
[c] Metered.

has an average thickness of about 35 feet on hillsides and hilltops and about 20 feet in valleys. It has low permeability but relatively high porosity, and, where saturated, it comprises an important storage reservoir that supplies water to fractures in the underlying bedrock. Its saturated thickness varies seasonally, ranging from 0 to 5 feet on hillsides and 5 to 10 feet in valleys. The fractures in the bedrock function primarily as conduits that transmit water from areas of recharge to areas or points of discharge.

Joints are abundant in surficial exposures of bedrock, but the size and frequency of openings apparently decrease rather abruptly at shallow depth. Wells typically penetrate only two or three low-yielding, narrow, water-bearing zones in the upper 100 feet of bedrock. Reported-yield, specific-capacity, and borehole-flow data from a few relatively deep wells indicate that most of the principal water-bearing openings occur above a depth of 200 feet.

Most of the wells inventoried are believed to penetrate only part of the zone of open fractures in the bedrock. However, it is believed that the specific capacity and yield of most existing wells would show only a moderate increase if the wells were drilled considerably deeper. These wells are considered to have specific capacities and yields that are fairly representative of the upper 100 feet of bedrock. As most of the principal water-bearing openings apparently occur above a depth of 200 feet, and because fracture permeability decreases at depth, it is considered unlikely that existing short-term specific capacities and yields could be more than doubled.

Yields reported for more than 500 wells range from less than 1 to 275 gpm and the median yield is 12 gpm. Short-term specific capacities range from less than 0.1 gpm per ft to 62 gpm per ft and the median value is 0.55 gpm per ft.

Analysis of short-term specific-capacity data on frequency graphs shows that a considerable range in values can be expected from wells drilled in any rock type or topographic position. Nevertheless, for any given frequency of occurrence, specific capacities of wells drilled in limestone and calcareous shale are about double those of wells drilled in non-calcareous sandstones and shales. Similarly, in a given rock type, the specific capacities of wells drilled in valleys are about double those of wells drilled on hilltops and hillsides.

Yields adequate for domestic needs are obtainable nearly everywhere in the study area, generally from wells that are less than 150 feet deep. Somewhat deeper wells may be required, however, on hillsides and hilltops underlain by calcareous rock types.

Rock units considered to have good yielding potential to wells are the calcareous shales and limestones of Late Silurian and Early Devonian age. Included in this category are the Wills Creek, Tonoloway, Keyser, Oriskany, Helderberg, Old Port, and Onondaga Formations. Of these, the Wills Creek

and Tonoloway Formations are the most important, because they underlie more valley area than the other formations.

Rock units considered to have fair yielding potential to wells include most of the noncalcareous shales and sandstones that do not underlie the steep slopes and crests of mountains and principal ridges. Units included in this category are the Martinsburg, Reedsville, and Bloomsburg Formations; the Shamokin and Mahanoy members of the Marcellus Formation; and the Sherman Ridge, Rush, Fort Littleton, and Catskill Formations.

Rock units considered to have poor yielding potential consist chiefly of the noncalcareous sandstones and shales that underlie the crests and steep slopes of mountains and ridges. Included in this category are the Bald Eagle, Juniata, Rose Hill, and Mifflintown Formations; the Turkey Ridge Member of the Marcellus Formation; and the Montebello Formation.

The exceptionally high specific capacity of 62 gpm per ft obtained for a test well drilled on a fracture trace in limestone supports conclusions drawn from a study in a nearby area that fracture traces mark zones of above-average permeability in carbonate rock units. The potential of fracture traces as a tool for prospecting for ground water appears to be great, but much additional evidence is required to fully evaluate their hydrologic significance. Especially needed are data regarding the yields of wells drilled on fracture traces in noncarbonate rocks.

Comparison of two dominant trends of fracture traces with two dominant trends of joints in the Loysville quadrangle shows that a northwest-trending joint set coincides approximately with a northwest-trending fracture trace set. However, a north-trending set of fracture traces has no corresponding joint set, indicating that these features are not necessarily joint-controlled, as has been assumed in some areas. Joints trend dominantly N 50°–60° E and N 20°–40° W; fracture traces trend dominantly N 0°–10° E and N 20°–30° W.

Ground water from all rock units in the Loysville and Mifflintown quadrangles is generally of good chemical quality. Water from calcareous shales and limestones generally has a dissolved solids content of 200 to 300 mg/l and is generally hard to very hard. Water from the non-calcareous shales and sandstones generally has a total dissolved solids content of 100 to 200 mg/l and is generally soft to moderately hard.

High concentrations of sulfate are present locally in water from the Wills Creek and Tonoloway Formations, and iron is troublesome locally in non-calcareous shales and sandstones. Reports of high concentrations of iron are most common from wells tapping black shales of the Martinsburg, Reedsville and Marcellus Formations and from wells in the interbedded sandstones and shales of the Mahantango Formation. Hydrogen sulfide gas is also present in noticable amounts in some wells in these units.

Conditions that may lead to bacterial contamination of wells exist in many areas. In areas of closely spaced homes served by on-lot sewage-disposal systems, shallow ground water around many drilled wells is bac-

terially contaminated. If the wells contain too little casing, or if the casing is inadequately sealed, natural hydraulic gradients may cause bacterially contaminated water to flow into the well. Even where a well is adequately constructed, pollution may result from polluted water that has entered the ground through a faultily constructed well nearby.

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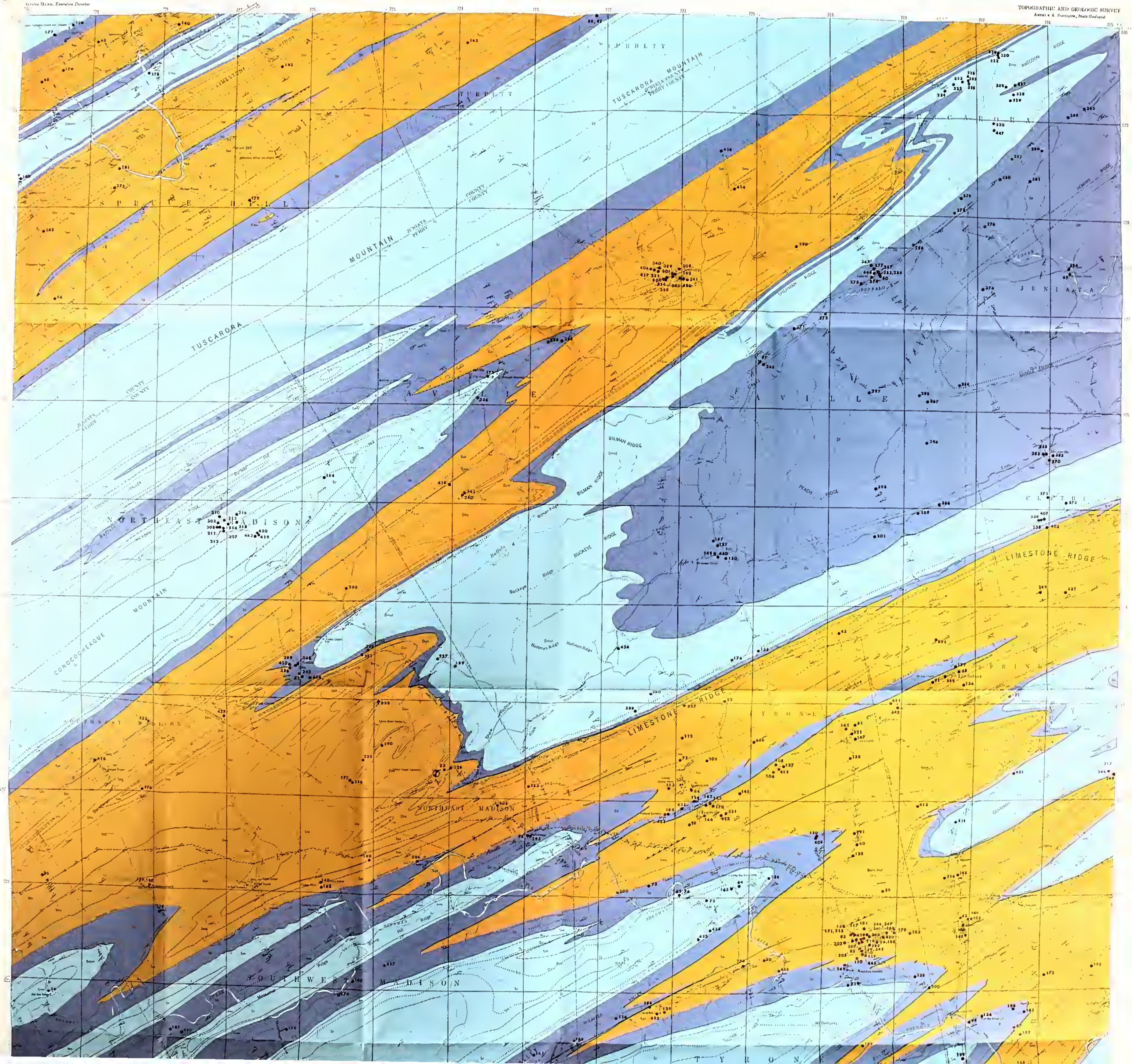

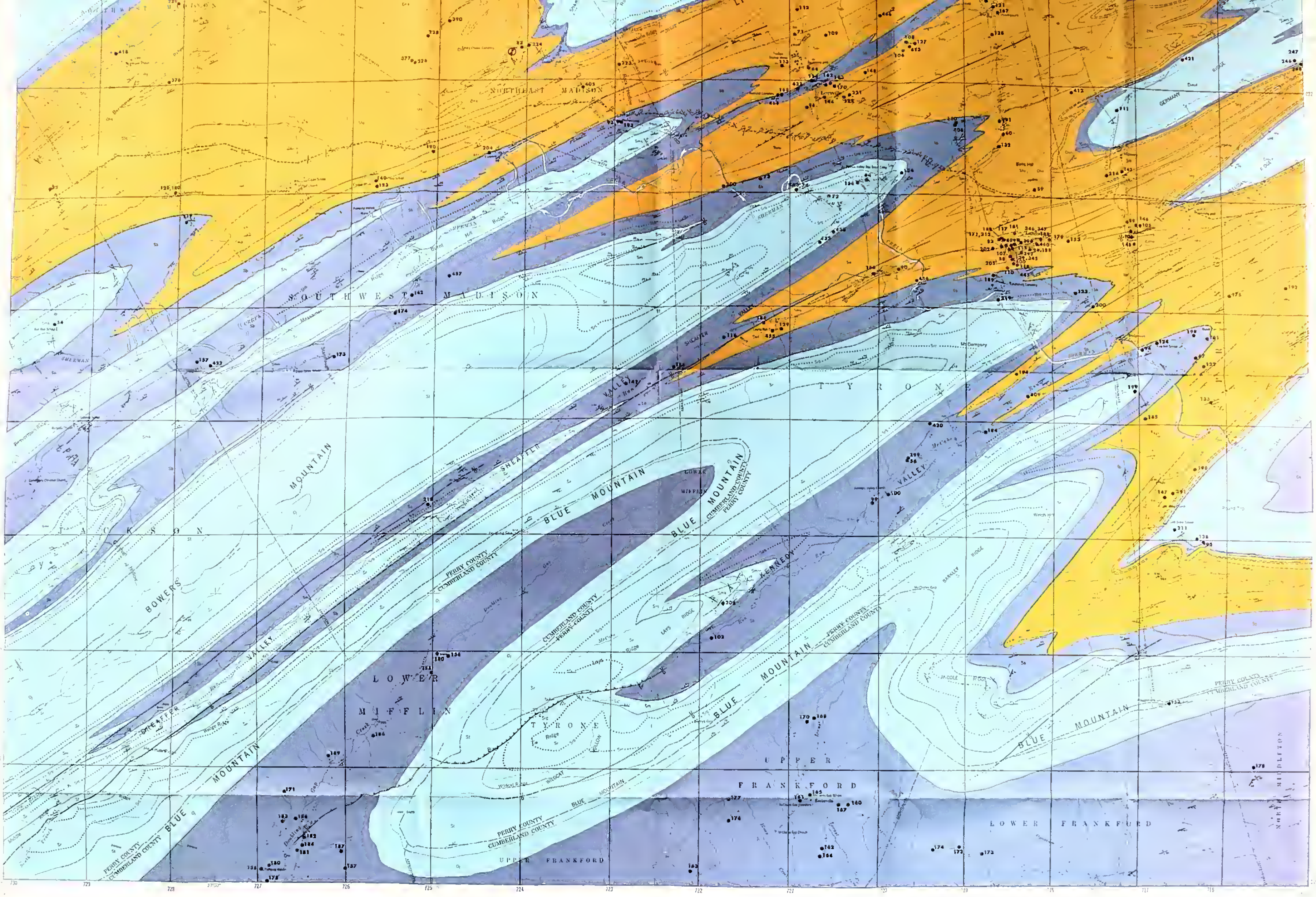

HYDROLOGIC MAP OF THE LOYSVILLE QUADRANGLE, SOUTH CENTRAL PENNSYLVANIA

HYDROLOGY BY HERBERT E. JOHNSTON

GEOLOGY BY JOHN T. MILLER, 1961

1 ½ 0 1 2 Miles

1000 0 1000 2000 3000 4000 5000 6000 7000 8000 9000 10 000 11 000 12 000 Feet

Contour interval 10 feet
Datum is mean sea level

EXPLANATION

WATER YIELDING POTENTIAL

The estimated potential for rock units to yield water to wells drilled to depths of at least 200 feet was determined largely from frequency graphs of specific-capacity data (see Figs. 10 and 11). The rocks were grouped into three categories—(1) good, (2) fair, and (3) poor—and were color coded as shown below. The potential of a few units was determined mainly on the basis of topographic and lithologic considerations, because no data were available. A relatively wide range in yields can be expected from wells in any topographic location, but valley wells generally will be the highest producers. Yields adequate for domestic use are obtainable in all rock units and at most topographic locations, generally from wells 50 to 170 feet deep.

Good

(Don, Dho, Dor, Dns, Sky, Sto, Sw, Swu, Swl)

Mainly limestone and calcareous shale

About half of the wells drilled in valleys may yield 30 gpm or more; about 25 percent may yield 80 gpm or more. Maximum yields obtainable from a small percentage of wells that tap solution openings in good hydraulic connection with nearby perennial streams probably are on the order of 300 to 400 gpm.

Fair

(Dck, Dfc, Df, Dr, Ds, Dmm, Dms, Sb, Om)

Mainly noncalcareous shales, interbedded shales and sandstones

About half of the wells drilled in valleys may yield 20 gpm or more; about 25 percent may yield 40 gpm or more. Maximum yields obtainable probably are on the order of 150 gpm.

Poor

(Dmo, Dmom, Dmt, Sm, Smm, Smk, Sr, St, Oj)

Mainly sandstone with some interbedded shale, and some limestone

These units generally underlie topographically high areas and yield only small supplies to wells. A few wells drilled in areas where these units underlie valleys may yield as much as 50 gpm.

ROCK UNITS

(Color coded according to yield potential)

Dck

Catskill Formation

Brownish-red siltstone, shale, and sandstone. Minor gray and greenish-gray beds. Well data sparse. Yielding characteristics of wells probably similar to other interbedded sandstone and shale units.

Dfc
Dfck

Catskill-Fort Littleton Transition Beds, Kings Mill Member (Dfck)

Interbedded grayish- to brownish-red and light-gray to greenish-gray siltstone, sandstone, and shale. Kings Mill olive-gray sandstone near base of unit. No well data available. Yielding characteristics probably similar to other interbedded sandstone and shale units.

Df

Fort Littleton Formation

Olive to olive-gray weathering sandstone and shale. Shale and siltstone dominant in lower part. Sandstone dominant in upper part. Median reported yield of wells is 9 gpm; range is 5 to 20 gpm. Median hardness of water is 4 gpg (grains per gallon).

Dr

Rush Formation

Mostly medium-dark to grayish-black shale (Hurket Member). In places it black and carbonaceous. At base is one or two feet of argillaceous limestone and (or) limestone. A zone of limestone nodules and calcareous shale is common at top. Median reported yield of wells is 15 gpm; range is 8 to 40 gpm. Median hardness of water is 4 gpg.

Ds

Sherman Ridge Formation

Interbedded olive-gray shale and sandstone. Impure, oolitic-hematite bed in lower middle portion. Sandstone dominant at base; shale dominant at top. Median reported yield of wells is 11 gpm; range is 1 to 50 gpm. Median hardness of water is 4 gpg.

Dmo, Dmm, Dmom, Dmot, Dmt, Dmt, Dms

Montebello Formation (Dmo, Dmom, Dmot)
Marcellus Formation
Mahanoy Member (Dmm)
Turkey Ridge Member (Dmt)
Shamokin Member (Dms)

Montebello Formation is dominantly clean to moderately clean sandstone in southeast with yellowish- to olive-gray siltstone and very fine-grained sandstone beds in lower portion. To north and west, average grain size decreases, and carbonaceous matter increases, to where Turkey Ridge and Mahanoy are separable from younger Montebello. Median reported yield of wells is 8 gpm; range is 2 to 30 gpm. Median hardness of water is 4 gpg.

Mahanoy Member dark gray to grayish-black, laminated, sandy siltstone and silty shale. Turkey Ridge Member olive- to dark-gray, medium- to thick-bedded sandstone, commonly speckled with rust spots. Shamokin Member dark gray to black, fissile, carbonaceous shale. Silty near top. Lower portion calcareous in places, with limestone and pyrite-marcasite nodules. Median reported yield of wells in the Mahanoy, Turkey Ridge, and Shamokin members are 8, 12, and 12 gpm, respectively; range is 1 to 30 gpm. Median hardness of water is 8 gpg in Mahanoy Member, 6 gpg in Turkey Ridge Member, and 10 gpg in Shamokin Member. Dissolved iron occurs in undesirable amounts in water from some wells in all three units. Hydrogen sulfide gas occurs in water from several wells in the shale units.

Don

Onondaga Formation

Upper part medium-gray, olive-weathering, argillaceous limestone. Grades down to olive-gray, calcareous shale underlain by dark-medium-gray shale containing phosphatic nodules at base. Median reported yield of wells is 8 gpm, range is 1 to 25 gpm. Median hardness of water is 10 gpg.

Dho, Dor, Dhs

Oriskany and Helderberg Formation undivided, Ridgeley Member (Dor) of Oriskany Formation, Helderberg Formation and Shriver Member of Oriskany Formation undivided (Dhs)

Ridgeley Member light- to olive-gray, fine-grained to conglomeratic, fossiliferous sandstone; thins to north and west. Lower unit light- to dark-medium gray, yellowish- to whitish-weathering chert, and cherty, medium-gray limestone, shaly near middle, sandstone lenses near base. Median reported yields of wells in the Ridgeley is 10 gpm; range is 5 to 20 gpm. Median reported yield of wells in Helderberg Formation and Shriver Member of the Oriskany Formation is 9 gpm, range is 1 to 100 gpm. Underlies ridges throughout much of the area. Wells on hillsides in these units commonly require more than 100 feet of casing. Median hardness of water is 1 gpg in the Ridgeley, and 7 gpg in the combined Oriskany-Helderberg.

Sky

Keyser Formation

Medium-gray, nodular, fossiliferous limestone. Median reported yield of wells is 9 gpm, range is 5 to 30 gpm. Median hardness of water is 15 gpg.

Sto

Tonoloway Formation

Medium-gray, laminated limestone and argillaceous limestone. Median reported yield of wells is 11 gpm, range is 1 to 275 gpm. Median hardness of water is 15 gpg. A few wells yield excessively hard water high in sulfate.

Sw, Swu, Swl

Wills Creek Formation
Upper Member (Swu)
Lower Member (Swl)

Upper member medium- to olive-gray, calcareous shale, argillaceous limestone, and siltstone. Grayish-red to olive sandstone (Landisburg Tongue) defines top. Lower member olive-gray and brownish-red interbeds of shale, siltstone, and minor sandy limestone. Median reported yield of wells in both members is 15 gpm, range is 5 to 100 gpm in upper member and 5 to 160 gpm in lower member. Median hardness of water is 15 gpg in upper member and 10 gpg in lower member. A few wells yield excessively hard water high in sulfate.

Sb
Sbb

Bloomsburg Formation
Bridgeport Member (Sbb)

Brownish- and some grayish-red shale, siltstone, and sandstone with local lentils of olive-gray sandstone and conglomerate (Sbb) near middle. Median reported yield of wells is 15 gpm, range is 1 to 100 gpm. Median hardness of water is 5 gpg.

Sm, Smm, Smk

Mifflintown Formation
McKenzie & Rochester Members undivided (Smm)
Keefer Member (Smk)

McKenzie Member medium-gray limestone with olive siltstone and shale at top. Intraformational breccia at base. Underlain by Rochester Member—a dark-medium-gray shale containing interbeds of medium-gray, crystalline limestone. Keefer Member medium- to olive-gray quartzitic sandstone containing lenticular interbeds of dark-gray shale. Median reported yield of wells is 10 gpm in McKenzie and Rochester Members, range is 1 to 50 gpm. Median reported yield of wells in Keefer Member is 6 gpm, range is 1 to 12 gpm. Median hardness of water is 9 gpg in McKenzie-Rochester, and 3 gpg in Keefer.

Sr, Srb, Src

Rose Hill Formation
Centre Member (Srb)
Cabin Hill Member (Src)

Olive- to medium-gray shale and siltstone with an upper (Srb) and lower (Src) gray-red sandstone unit. Median reported yield of wells is 12 gpm; range is 2 to 35 gpm. Median hardness of water is 5 gpg.

St

Tuscarora Formation

Light-gray, quartzitic sandstone. Median reported yield of wells is 6 gpm, range is 1 to 10 gpm. Median hardness of water is 2 gpg.

Oj

Juniata Formation

Brownish- to grayish-red sandstone (quartzitic in upper part), siltstone, and shale. Conglomerate beds (Bald Eagle Formation?) at base. No well data available. Yield characteristics probably similar to Tuscarora Formation.

Om

Martinsburg Formation

Dark- to medium-gray, yellowish- to olive-weathering shale, with silty and sandy interbeds. Median reported yield of wells is 12 gpm, range is 2 to 40 gpm. Median hardness of water is 6 gpg. Dissolved iron and hydrogen sulfide gas occur in undesirable amounts in water from several wells.

Definite contact

Approximate contact

Inferred contact

Approximate outcrop of member

High angle (40°-90°) fault with dip indicated
U, upthrown side, D, downthrown side

Low angle (0°-45°) reverse fault
Saw teeth on side of upper plate indicate dip

Strike and dip of beds

Strike and dip of overturned beds

Strike of vertical beds
Placement of 90 indicates tops of beds

Horizontal beds

Generalized strike of beds tightly folded or otherwise contorted on small scale

Strike and dip of beds. Tops of beds problematic

Approximate strike and dip

Strike and plunge of axis of minor anticline

Strike and dip of axial plane of minor overturned anticline

Strike and plunge of axis of mappable anticline

Strike and plunge of axis of mappable syncline. F indicates minor faulting along axis

Underground pipline

38
Water well and number

Stream gage

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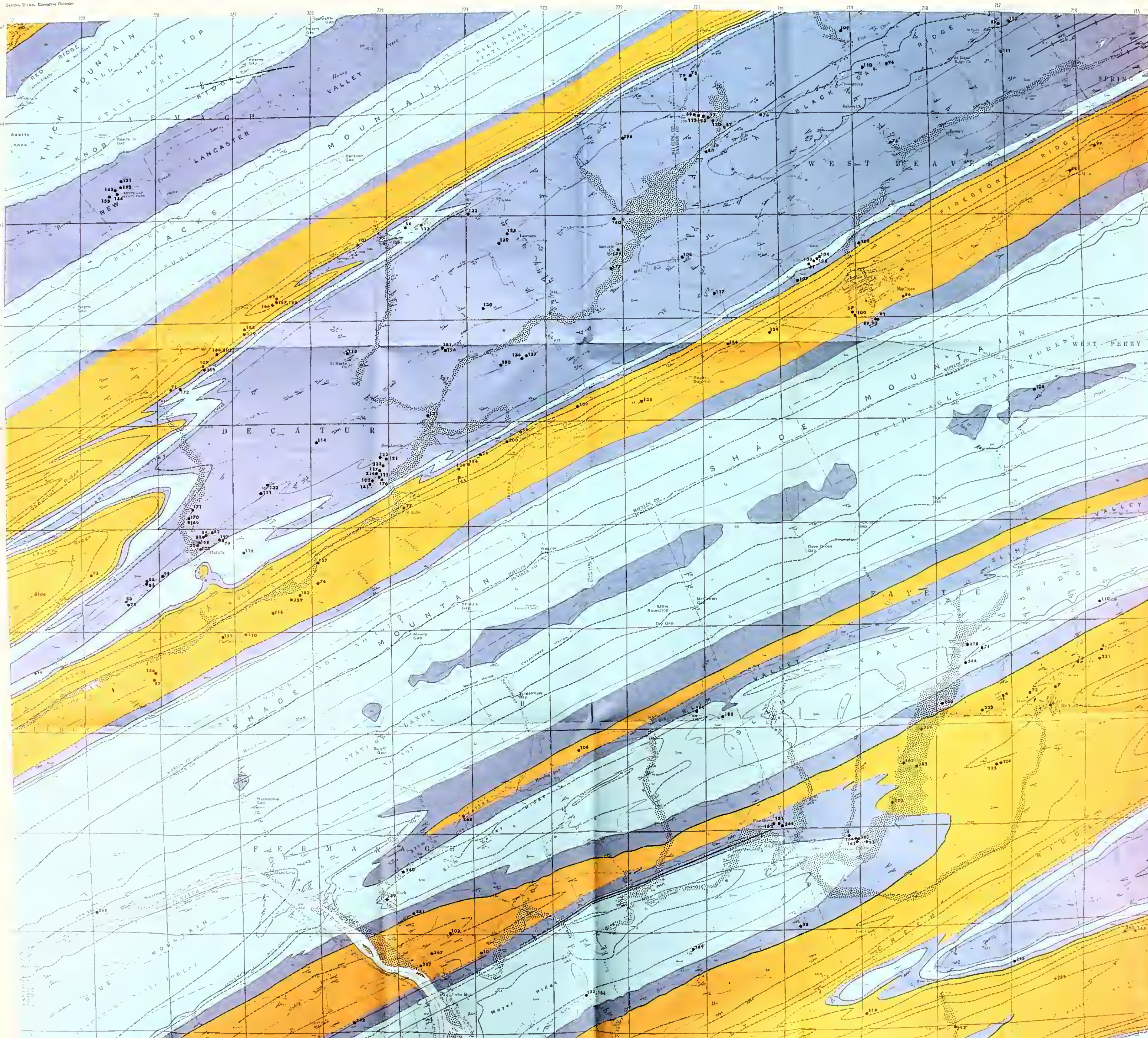
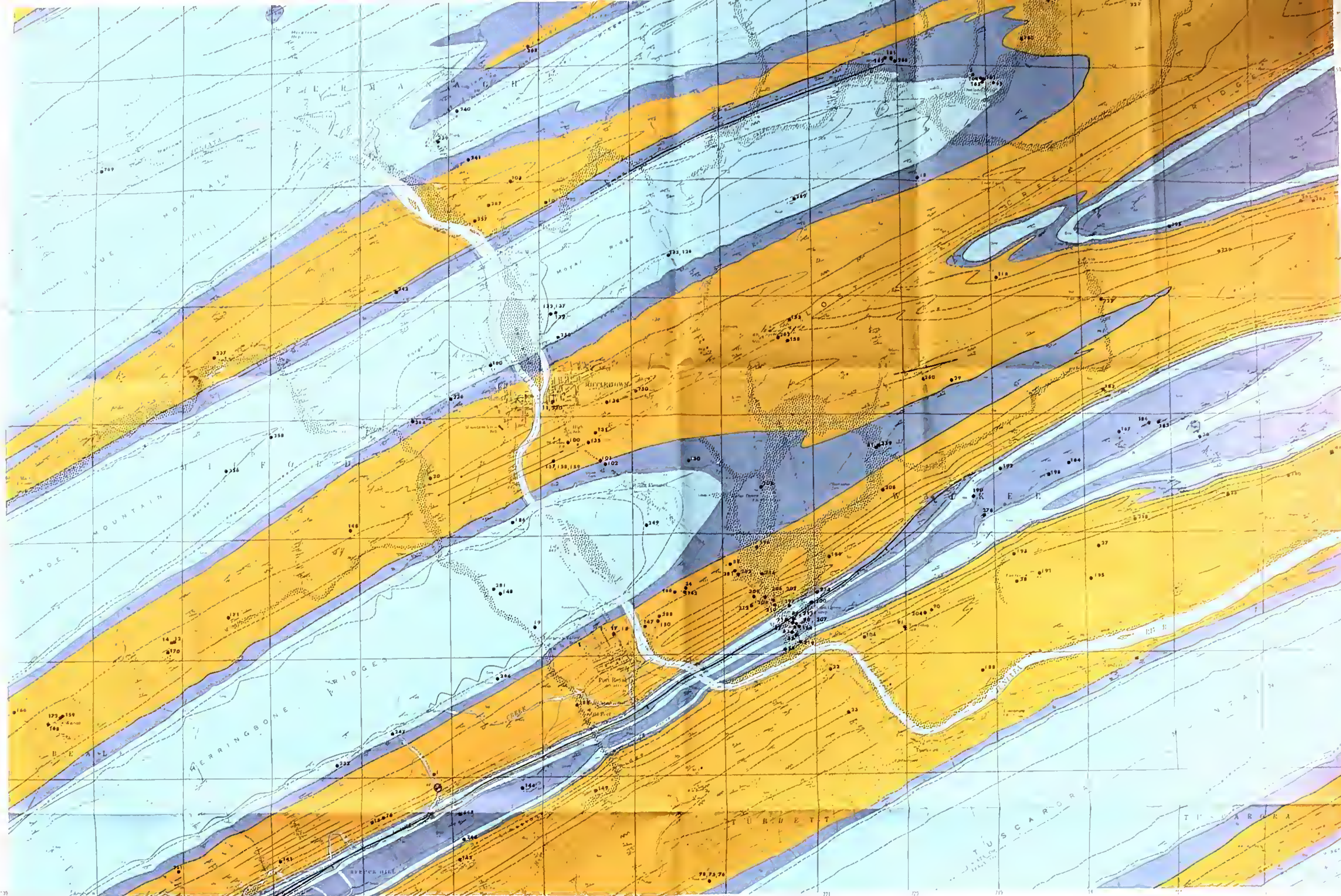
IRVING HAND, *Executive Director*

TOPOGRAPHIC AND GEOLOGIC SURVEY
ARTHUR A. SOCOLOW, *State Geologist*





HYDROLOGIC MAP OF THE MIFFLINTOWN QUADRANGLE, SOUTH CENTRAL PENNSYLVANIA

HYDROLOGY BY HERBERT E. JOHNSTON

GEOLOGY BY RICHARD R. CONLIN AND DONALD M. HOSKINS, 1962

EXPLANATION

WATER YIELDING POTENTIAL

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Good

Mainly limestone and calcareous shale

Fair

Mainly noncalcareous shale and interbedded sandstone and shale

Poor

Mainly sandstone and shale; some limestone

ROCK UNITS

(Color coded according to yield potential)

Floodplain and Terrace Deposits

Df — Fort Littleton Formation

Dr — Rush Formation

Dmh — Mahantango Formation

Dm, Dmm, Dmt, Dms — Marcellus Formation: Mahanoy Member (Dmm), Turkey Ridge Member (Dmt), Shamokin Member (Dms)

Don — Onondaga Formation

Do — Old Port Formation

Sk — Keyser Formation

Sto — Tonoloway Formation

Sw, Swu, Swl — Wills Creek Formation: Upper Member (Swu), Lower Member (Swl)

Sb — Bloomsburg Formation

Sm, Smk — Mifflintown Formation: McKenzie & Rochester Members undivided (Smm), Keefer Member (Smk)

Sr — Rose Hill Formation

St — Tuscarora Formation

Oj — Juniata Formation

Ob — Bald Eagle Formation

Or — Reedsville Formation

Os — Salona Formation

Ons — Nealmont Formation